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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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33 West Thirty-ninth Street, New York

American Welding Society

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JOURNAL

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 6 MAY, 1927 Number 5

NEW OFFICERS AND DIRECTORS OF SOCIETY

At the Annual Meeting the following officers and directors were unanimously elected to serve for the year 1927-28.

President—F. M. Farmer.

Senior Vice-President—J. H. Edwards.

Southern Division Vice-President—R. L. Shepherd.

Pacific Coast Division Vice-President—G. O. Wilson.

F. M. FARMER
President A. W. S., 1926-28

Directors at Large—J. J. Crowe, W. H. Gibb, H. S. Smith, W. C. Swift.

A signal honor was bestowed upon President F. M. Farmer in his re-election to serve as president for another year. This is the first time that a president has served in this capacity for more than one term; his immediate reelection having been made possible by a change in the by-laws. President Farmer has given the Society his whole-hearted support and attention. As the chief executive, official chairman of the Executive Committee, Board of Directors and representative of the Society in many capacities, he has given unstintingly of his time. Through his efforts and with the assistance of the other officers and directors, the Society has emerged at the close of the first year of his administration in a stronger position than ever.

J. H. Edwards, assistant chief engineer of the American Bridge Co., was elected senior vice-president of this Society. Mr. Edwards is well known to most of our prominent members through his sympathetic understanding of the possibilities of welding in the structural field. Mr. Edwards has served on the Executive Committee and is chairman of the newly organized Structural Steel Welding Committee.

R. L. Shepherd, Southern editor of the *Electrical World*, Birmingham, Ala., formerly assistant engineer editor of *Electrical World*, was elected to serve as vice-president of the Southern Division of the American Welding Society. Mr. Shepherd has served as chairman of the Meetings and Papers Committee.

G. O. Wilson, secretary of the Consulting Board of Engineers of the Standard Oil Company of California, was elected to serve as divisional vice-president of the Pacific Coast. Mr. Wilson has served as chairman of the San Francisco Section and is thoroughly familiar with the several welding processes and the needs of the Pacific Coast Division.

The newly elected directors of the American Welding Society are outstanding figures in the welding industry. They are respectively: J. J.

Crowe, Air Reduction Sales Company, New York, N. Y.; W. H. Gibb, president, Gibb Welding Machines Co., Bay City, Mich.; H. S. Smith, chief engineer, Prest-O-Lite Co., New York, N. Y.; W. C. Swift, research engineer, The American Brass Co., W. Alexandria, Ohio.

EIGHTH ANNUAL MEETING OF THE AMERICAN WELDING SOCIETY

The Eighth Annual Meeting of the American Welding Society came to a successful close, Friday afternoon, April 29. The outstanding events of the meeting were the very highly successful technical sessions and committee meetings.

On the day preceding the formal opening of the Annual Meeting were meetings of the Nomenclature and Executive Committees. Considerable progress has been made in arriving at tentative agreements on nomenclature, definitions and symbols to be used for the more common terms in the welding field.

On Wednesday morning there was a combined meeting of the Gas and Electric Arc Welding Committees of the American Bureau of Welding. The Electric Arc Welding Committee concentrated its attention on analysis of the test results of the Emergency Fleet samples made during the war to study fundamentals in connection with electric arc welding. It is hoped that a final report of this committee will be available some time during the coming year. The Gas Welding Committee devoted its attention to consideration of a preliminary report by a subcommittee of the San Francisco Section who are making a study of the properties of welds when subjected to high temperatures. These preliminary studies indicate results which are very favorable to both arc and gas welding under these conditions.

The Annual Meeting of the American Bureau of Welding was held on Wednesday afternoon. The following officers were reelected to serve for another year:

C. A. Adams, Director; Harvard Engineering School.

H. L. Whittemore, First Vice-Director; Bureau of Standards.

A. D. Risteen, Second Vice-Director; Travelers Insurance Co.

W. Spraragen, Secretary; National Research Council.

The annual report of the Bureau included a review of the early history, its organization, method of functioning, some of the outstanding accomplishments and plans for future activities. A recommendation that the electric arc, gas and thermit welding committees be discharged and work concentrated on pressure vessels, structural steel, welded rail joints and welding wire investigations, was favorably acted upon. An attempt is being made to interest leading universities in a study of some of the fundamental problems in connection with welding.

On Wednesday evening, a meeting of the Structural Steel Committee was held, at which time consideration was given to the "Procedure Specifications" specifying in exact detail just how each of the specimens should be welded, called for in the test program. These "Procedure Specifications" include, also, instructions to inspectors. It was agreed that a preliminary trial should be made under the auspices of Professor Gillespie of the University of Toronto, in following out these "Procedure Specifications."

The technical sessions were opened on Thursday with a report of the Tellers Committee and a report of the year's activities by President F. M. Farmer. The meeting was then turned over to E. H. Ewertz, presiding officer of this session. Ten brief reviews were presented, giving a summary of research activities in the welding field in the past three years by some of the leading companies identified with the American Welding Society. Several of these reports were printed in the April issue of the Journal, others are given in this issue and the remainder will be published in the June number.

The presiding officer of the Technical session in the afternoon was E. M. T. Ryder, Senior Vice-President. In order to indicate the wide field of application of welding, six specific applications to production welding work were selected, representing the several welding processes. A series of short papers were given, illustrated by lantern slides, each dealing exhaustively with one specific application including cost figures, design data, technique of welding, jigs, methods of testing, products, etc.

The annual dinner dance of the American Welding Society was held at the Hotel Commodore on Thursday evening. Following the precedent established last year the dinner was

followed by a dance. Special entertainment was also included on the program. A unique feature of the occasion was the Presidential Address by President F. M. Farmer. This address is given elsewhere in this issue. The Toastmaster, Thomas Wry, introduced the newly elected officers and directors of the Society and also a few of the prominent members identified with the Society's activities.

The Board of Directors' meeting was held on Friday morning. The actions taken by the Executive Committee during the year were carefully reviewed and approved. Appointment of officers to standing and other special committees were made at this time. Among these are included:

Treasurer—C. A. McCune.

Secretary and Assistant Treasurer —M. M. Kelly.

Finance Committee—C. A. McCune, Chairman; E. M. T. Ryder, J. J. Crowe, A. G. Oeher, C. W. Bates.

By-Laws Committee—A. M. Candy, Chairman; with representatives of the Sections.

Membership Committee — A. E. Gaynor, J. W. Meadowcroft, A. G. Bissell, R. L. Browne, W. Spraragen, Secretary.

Meetings and Papers—P. W. Swain, Chairman; T. C. Fetherston, L. R. Gurley, E. VomSteeg, C. J. Holslag, W. R. Hulbert, F. E. Rogers, W. Spraragen, Secretary.

Executive Committee—J. H. Edwards, E. H. Ewertz, H. S. Smith, J. J. Crowe, C. A. McCune, A. M. Candy, D. H. Deyoe, J. H. Deppeler, J. W. Meadowcroft, A. G. Oeher, F. M. Farmer, Chairman.

The last session of the Annual Meeting was a meeting of the Joint Committee on Pressure Vessels of the American Society of Mechanical Engineers and the American Bureau of Welding. This was one of the best attended sessions of the meeting. A preliminary test program was submitted by the subcommittee on Tests and after the most careful consideration was adopted with minor suggestions for additions. It is hoped that this work will be undertaken very shortly.

THE FUTURE OF THE AMERICAN WELDING SOCIETY

(Presidential address presented by President F. M. Farmer at Annual Dinner, A. W. S., April 28, 1927.)

The Society is now eight years old. It has over eight hundred members, it has a substantial cash surplus in its treasury, and it has established itself as an organization serving a useful purpose in industry. Although as yet a small society, we have made a definite beginning in carrying out our avowed purpose of advancing the science and art of welding.

Now that we are well started on our way it would seem advisable to consider the general policy which we should adopt for our future development. The field of application of welding has been expanding rapidly in a wide variety of the metal-fabricating industries. We are on the eve of a period of still greater expansion because the welding of steel structures is near at hand. It is, therefore, a particularly appropriate time to consider our future policy, and I propose to devote this address to a discussion of that subject.

The American Welding Society has been functioning, since its organization, in much the same manner as do the professional engineering societies. That is to say we promote the art and science of welding through such activities as meetings of the national body and the sections where technical papers are read and discussed, through the publication of a monthly journal and by means of an annual exhibition at which the progress of the art is shown. We advance the art by the organization of cooperative research on the important problems which have arisen in the application of welding. We do a considerable amount of standardization work. But these are all strictly technical activities. Is this as far as we should go? Do activities of this kind supply all the needs of the industry insofar as an organization like ours can properly supply them? My own view is that they do not.

We will all agree that we should be doing just what we are doing. Furthermore, these activities should be developed and expanded just as much as possible. We should build up our resources and the headquarters staff so that more active assistance can be given to our sections in making their technical meetings more valuable. We should make our journal the recognized record of the advances in welding and the recognized technical authority therein. We should firmly establish the principle of cooperative research in problems of common in-

terest, recognizing that such problems will continue to arise as the art develops, and that the sooner we adopt this method of solving these problems, the easier it will be and the greater will be the resulting benefits and economies.

But the science and art of welding can be promoted by other types of activities, and perhaps even more rapidly than by those I have mentioned. Furthermore, a new industry is being founded on the art of welding. The prosperity of that industry contributes to the advancement of the art itself. We should, therefore, serve it in any proper way which will assist in its expansion and development, and be the agency for the solution of the non-technical problems which always confront an industry, particularly a new one. In short, the policy of the American Welding Society should be one of aggressive leadership in the welding field and of activity in all directions which will promote welding.

One of the most important of the problems in which this broader policy would involve us is that of obtaining uniformly high quality in commercial welding. The materials and the conditions may be right, but sound welding requires sustained conscientious effort on the part of the welder—that pride in craftsmanship which was in former days the basic equipment of the artisan but which is now the exception rather than the rule. While the development of automatic machine welding has solved this problem in some cases, manual welding must be used in many others. An important example is steel structures. Here the confidence of construction engineers, municipal authorities and the general public in the uniform soundness of welding throughout every inch and every foot of the structure must be established before the welding process will attain the fullest measure of success.

How is this to be accomplished? The present activities of the Society are helpful in raising the standards of workmanship but they are quite inadequate and are too slow. Licensing of welders under the auspices of the Society has been discussed and it would seem to offer a very effective method if the Society were large enough and influential enough to make its license acceptable as a guarantee of good welding. However, we are not yet in that position and furthermore there are a number of practical difficulties, political and otherwise, in the way of a satisfactory licensing procedure.

A compromise alternative which has possibilities is for the American Welding Society to enlist the voluntary cooperation of employers of welders in a plan whereby only welders who complied with rigid standards set up by the Society would be employed on work involving safety to life and property. The approval of the Society might carry with it the privilege of using a suitable, registered emblem, indicating that the work on which it appeared had been welded under this plan. With proper publicity and the whole-hearted support of all elements of the welding fraternity, this emblem could be made the hall-mark of reliable workmanship and thus insure the confidence of the public.

Another form of activity in which we should engage is that having to do with legislation. We have, up to the present time, avoided taking any active part in legislative discussions respecting safety measures involving welding. I feel, however, that we should be assisting the commercial interests of both the manufacturers of welding equipment and the users of the welding processes, where legislation affecting their affairs is concerned, by being officially represented at hearings and by putting before legislation-making bodies, reliable information. Most of the legislation which we feel is unjustified is the result of misinformation. It seems to me that we can render a real service to the welding fraternity in this direction which will become more and more valuable provided we are careful to avoid doing those things which have in the past cast suspicion on the motives of group activities of this kind.

Another service which I think this Society could properly look forward to undertaking is that of furnishing expert advice to the users of the welding processes. The best interests of all concerned with the commercial expansion of the art are advanced if the type of welding best suited for each particular application is being used and is being used properly. Until competent consulting engineers have been developed in this field it would seem that this should be a proper function of the Society.

We could very appropriately, I believe, devote more energy to propaganda activities. I do not refer to the usual type of commercial propaganda because welding does not need

That is to say we promote the art and research in problems of common in-

that kind of advertising from us to assist in selling it to industry. The manufacturers of apparatus and supplies will take care of that. But there is justification for cooperative propaganda which will raise the standards in the welding field—ethical standards as well as technical standards. I have already referred to the problem of poor workmanship and licensing or certification as a means of eliminating it. Educational influences must also be utilized just as far as practicable. For example, we should not only develop standard procedures for the various methods of welding but provision should be made for distributing them widely at a nominal cost. Similarly, the training courses, which already have been prepared at a considerable cost of time and money, should be available for distribution at as low a cost as practicable because it is one of the best kinds of educational material but unfortunately their printing and distribution is being greatly delayed because of the question of expense. The Society should be the channel for spreading welding knowledge of the right kind by means of lectures, moving pictures, bulletins and an expanded JOURNAL. More activities of this kind will have the incidental advantage of assisting in building up that group consciousness which is essential to cooperation in the industry —a matter I touch upon elsewhere.

Membership is a particularly important matter in this connection. Success in some of these broader activities of the kind proposed requires a large membership. Furthermore the majority of our membership should be representative of the users of the welding process—that is, superintendents, supervisors, engineers and others responsible for the quality of welding. The representatives of the manufacturers of welding apparatus and supplies have taken the most interest in the Society and consequently their influence is quite properly predominant at the present time. But if we are to attain the position which we should have, the balance of power, if any, should, as a matter of policy, be with the larger users of welding and the independent interests. Such a condition not only assists in raising the ethical and technical standards of welding but insures a more influential organization in matters involving the interests of the general public. In my opinion our energies should at once be concentrated in enlarging our membership among the users of the various welding processes. They, after all, are reaping the greatest rewards through the advancement of the art and should have the greatest interest in the growth of the Society.

I cannot refrain from discussing a condition which I have observed in the welding fraternity and which might prove to be a serious handicap to the Society in attaining the position which I am picturing, and also, I venture to suggest, the maximum advancement of the art. I refer to the lack of complete cooperation between the various manufacturers of apparatus and supplies.

The acrimonious discussions of our earlier days between the proponents of the various processes were detrimental to their own interests because of the adverse effect on the prospective users of welding. That is a thing of the past and we no longer have what might be called *destructive* cooperation but I fear we still have too much *passive* cooperation. For instance when a meeting dealing with one process is held there is apt to be a conspicuous absence of those interested in other processes. This attitude not only reduces our strength as a Society but has an unfavorable influence on our friends, the users of welding. Furthermore, common sense would seem to indicate that each group should embrace every opportunity to keep informed on what competing groups are doing. Rivalry should be friendly rivalry with commercial competition based on superior merit rather than destructive criticism of a competitor's process, either active or implied.

Other evidence of lack of cooperation has come to my attention. During a visit to one of our Sections I was very solemnly assured that one faction of the welding industry controls the Society and that, therefore, the other factions have little to gain by taking an interest in its affairs. In another city within the same week I was told exactly the same thing except the factions were just reversed! Only recently I received a letter from a manufacturer in one of our groups, stating that his group received no consideration in Society activities because it was controlled by another group. Now of course we all know that there is no foundation in fact for any of these statements. Nevertheless they indicate a lack of that mutual confidence and whole-hearted cooperation which are necessary for the sound and conservative develop-

thermore there are a number of practical difficulties, political and other-

the usual type of commercial propaganda because welding does not need

ment of welding as a tool of maximum usefulness in our industrial progress.

Let us subscribe to the sentiment recently expressed by Owen D. Young that technical standards are important in industry but no less important are standards of conduct—standards which make for cooperation and constructive advancement of industry rather than dissension and destructive competition. Finally let us all remember that in any case the law of the survival of the fittest will prevail and that welding process which proves to be the most effective and the most economical will be the one to endure.

In concluding this brief address may I urge your serious consideration of our policy at this opportune time in the history of welding? Shall it be one of broad, aggressive leadership in the welding field with service in all directions which will promote the art and the industry or shall we go on as we have been going and confine our activities strictly to technical matters? Gentlemen, it is for you to decide.

WELDING SOCIETY ANNOUNCES ESTABLISHMENT OF THE MILLER MEDAL

At the annual dinner of the American Welding Society, held in New York on April 28, F. M. Farmer, the society's national president, announced the donation of an award, the gift of Samuel Wylie Miller, to be presented by the society annually in appreciation of work of outstanding merit in advancing the art and science of welding. The award is a gold medal, which will be known as the Miller Medal.

Mr. Miller has been one of the outstanding figures in the advancement of welding ever since its commercial inception. He is a past president of the American Welding Society, and a prominent and active member of the Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, and other scientific and engineering organizations. He has been long noted for his energetic insistence upon high quality and dependable workmanship and upon the development of welding by all processes along lines scientifically well founded.

In establishing this award, the details for the administration of which are not yet decided upon, Mr. Miller's object is to promote an appreciation of better welding and to encourage the study of those fundamentals which will lead to raising the quality of work done by the average operator.

In accepting the administration of this award Mr. Farmer outlined briefly the history and ideals of its donor, and expressed himself as being particularly gratified that during his administration the Welding Society should be granted the privilege of managing such an important contribution to the improvement of the welding industry.

ATTENDANCE AT ANNUAL MEETING

It is safe to say that all of the several hundred members and guests who attended the various technical and other sessions of the Eighth Annual Meeting of the American Welding Society were well repaid for the time and expense incurred. Although many of the technical papers and part of the discussions will be published in the JOURNAL, nevertheless, the benefits from reading of this material does not compare with the first hand information obtained at the meeting, seeing the lantern slides and talking with workers and leaders of the welding industry. Much of the discussion at the committee meetings will, of course, not be published.

The registration was ably handled through F. E. Rogers of the Air Reduction Sales Co., who is chairman of the New York Section.

ENTERTAINMENT OF LADIES AT ANNUAL MEETING

A unique feature in connection with the Eighth Annual Meeting of the American Welding Society was a provision for the first time for the entertainment of the wives and daughters of the members of the Society. This entertainment included a luncheon at the Cornell Club, an automobile ride to various points of interest around the city, a theater party and the annual dinner dance. Special thanks are due to the two hostesses, Mrs. F. M. Farmer and Mrs. A. F. Keogh, and to the dinner committee under the chairmanship of A. E. Gaynor.

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cooperation which are necessary for the sound and conservative develop-

ANNUAL REPORT OF THE PRESIDENT

(Presented at Opening Session, Annual Meeting of A. W. S.)

The by-laws of the Society prescribe that the president shall submit a report of the activities of the Society at the annual meeting. In accordance with that mandate, the following report is submitted.

Membership

The Society had a total of 854 members in good standing on March 31, 1927, distributed among the various classes as follows:

Class A	51
Class B	310
Class C	262
Class D	226
Class E	3
Class F	2
Total	854

There was a loss of 200 members during the year and a gain of 209 members, leaving a net gain of 9 members. While this would indicate practically no growth of the Society so far as total membership is concerned, an analysis of the changes in the various classes shows that there was a net gain of 2 Class A, 37 Class B and 4 Class C members—the net loss being in Class D members. In other words, while the total number has not changed appreciably, the average quality of memberhip has been markedly raised. We all recognize that, while we want all the Class D members we can get, our strength and influence lies in our Class A, B and C members.

However, a loss of nearly 25 per cent in gross membership is much too large, particularly when this includes 6 Class A members, 42 Class B and 51 Class C. A certain amount of loss in membership is to be expected but it should not be over 10 per cent at the most. It is recommended that a study should be made of these resignations to determine the cause so that we can, if possible, profit by the experience.

It is further recommended that the Membership Committee for the incoming administration, in addition to undertaking an energetic campaign in cooperation with the Technical Secretary for additional Class A and Class B members, carefully scrutinize our membership list. There appears to be many cases where the member, as listed, is not in the appropriate class. There are many Class D members, for example, who should be Class C or even Class B members.

Financial

The finances of the Society continue in good condition. The total receipts for the Society year ending March 31 were $28,164.60, an increase of about $3,000 over the previous year. Disbursements total $27,225.58, which is also an increase of about $3,000 over last year. Nearly $1,000 was added to our reserve fund, which now totals $8,681.93.

The details of our financial operations for the year will be found in the Treasurer's annual report.

Meetings

The usual two meetings of the Society were held, the Annual Meeting in New York in April and the Fall Meeting in Buffalo. Both meetings were very successful—particularly the one in Buffalo, where the attendance at the technical sessions was frequently over 200.

The Sections have continued to function actively during the year and meetings of most of the Sections have been held more or less regularly once a month, either as a Society Section meeting or a joint meeting with other organizations.

There appears to be a tendency on the part of the officers of some of the Sections to look to headquarters too much for help in making Section meetings successful. It ought not to be necessary to point out that that intangible thing called inspiration is essential for a thriving and successful Section and that it must come from the Section itself. It cannot be furnished by headquarters. If there is not sufficient interest and initiative available in a Section to make it successful, it is very questionable if it should exist at all.

On the other hand, the national organization should assist the Sections in every way possible, and it is hoped that the appointment of a Technical Secretary, which includes this assistance as a part of his duties, will contribute materially to Section activities.

Journal

The JOURNAL has grown to nearly 1000 pages per year—about 75 per cent being Society, editorial and technical matter, while about 25 per cent is advertising and circular matter. It continues to be a substantial source of revenue to the Society.

The more liberal policy adopted during the year which admits signed editorials on subjects of interest to the welding fraternity is a step in the right direction. It is to be hoped that our members will freely avail themselves of this opportunity.

New Sections

One new Section, the Canadian Section, has been organized during the year. It began functioning as a formal Section of the Society on March 24, 1927, with a membership of 28 members.

The Executive Committee has adopted an informal rule that applications for formal authority to function as a Section will not be granted until there are 25 paid-up members for the proposed Section and that of these at least 15 shall be Class A or Class B members.

Executive Committee

The Executive Committee, which carries on the governing functions of the Board of Directors between its two meetings per year, has held six meetings during the Society year ending March 31, 1927.

The attendance at these meetings has been excellent, the proportion of members of the committee attending each meeting being very high. The Society membership is to be congratulated on having its affairs guided by so conscientious a group.

This committee disposes of many routine matters and questions of minor importance during the year. The more important actions which have been approved by the Board of Directors are indicated under various appropriate headings in this report.

American Bureau of Welding

The bureau, which is the research department of the American Welding Society, has on hand four major research investigations in the welding field, as follows:

Welded Rail Joints.—This investigation has been under way for some years and a total of five reports have been issued—the last two occupying 97 pages in the JOURNAL, having appeared this year.

Welding Wire Specifications.—A very comprehensive chemical and metallurgical study of a large number of samples of welding wire of all kinds—both that which make good welds and that which make poor welds—has been made. The committee hopes that these results will settle the long standing controversy over what makes a welding wire "bad" and what makes it "good." A report is being compiled and will be published shortly.

Welded Pressure Vessels.—A more comprehensive investigation of welded pressure vessels to supplement that made some years ago has been inaugurated during the year as a joint project with the American Society of Mechanical Engineers. A widely representative committee has been set up and a program has been developed which will cost about $25,000 and will require about two years to complete.

Welding Structural Steel.—Another new project launched during the year is an investigation of the general problem of welding steel structures. The steel fabricators and construction engineers need to know what minimum strength of welded joints in standard designs could be counted on in representative welding shops so that safe design constants can be developed. Furthermore, more data are needed in order to develop the forms of joints which are more efficient than those based on standard riveting practice.

A very comprehensive program has been developed by a committee under the chairmanship of Mr. J. H. Edwards, assistant chief engineer of American Bridge Company. The cost of the work, which is estimated to be $25,000, is being financed by the steel companies, the structural steel interests, through the American Institute of Steel Construction, and the welding industry. This project is also expected to require two years to complete.

A.S.M.E. Boiler Code

Section VIII of the A.S.M.E. Boiler Code, which deals with welded joints in pressure vessels, has been given a great deal of attention by the Executive Committee since its promulgation. There have been several conferences between representatives of the Society and the Boiler Code Committee, including the heads of both organizations. It is believed that the Boiler Code Committee is sympathetic to our objections to the restrictions on welding now in the Code but that they do not feel justified in taking formal action in the way of a revision until the additional tests are completed in the new investigation of welded pressure vessels about to be undertaken by the joint committee of the A.W.S. and the A.S.M.E. These are expected to pro-

vide concrete facts and evidence on which they can base formal action.

Annual Exposition

The successful exposition held in connection with the 1926 Fall Meeting at Buffalo was the second one sponsored by the Society. It demonstrated that this activity is no longer an experiment but should be considered a permanent feature of our Fall Meeting. That being the case, it seemed desirable to change the policy which had prevailed in the handling of these expositions. The Boston and Buffalo expositions were handled entirely by the local members. This not only means a heavy burden because there is a tremendous amount of detail work involved but every time we went to a new city a new group had to learn how to organize a successful exposition. This, of course, is an inefficient arrangement.

The Executive Committee appointed a Special Committee to investigate and recommend a permanent scheme for handling these expositions in the future. Upon recommendation of this Committee arrangements have been effected to join with the Exposition of the American Society for Steel Treating which is to be held at Detroit in September. A satisfactory arrangement has been effected whereby the A.S.S.T. takes care of all the details of our section of the exposition and we get a fair percentage of the net profits from the sale of space.

These expositions can be made a very effective agency of the Society in carrying out its constitutional objects. A well planned exhibition conducted in a dignified manner consistent with the standing of the American Welding Society has a great educational value. Incidentally, it has a not unimportant advertising value to the Society. The arrangement made with the American Society for Steel Treating should make this our most successful exposition because the attendance will be far larger than we could possibly expect otherwise.

Changes in By-Laws

The following change in Article IV, Section 2, which would permit the re-election of the President was recommended by the Committee on Revision of By-Laws to the Executive Committee. The Executive Committee approved the change, as also did the Board of Directors. It subsequently received the majority approval of the membership by letter ballot.

"The President shall be elected by the Society for a term of one year. He shall be eligible for re-election to the same office for the immediately following year only."

Other changes recommended by the Revision of By-Laws Committee and which have received the approval of the Executive Committee are to be presented to the Board of Directors at their meeting during this Annual Meeting of the Society. These changes are as follows:

Article I, Section 2.—Drop letters designating various classes of membership and designate members by outstanding titles such as Sustaining Members, Members, Associate Members, Operating Members, Honorary Members and Student Members.

Article III.—Change caption from "Organization" to "Section Organization."

Article IV, Section 3.—Revise so that it reads:

"A Senior Vice-President residing in the vicinity of Headquarters shall be elected by the Society for a term of one year. He shall be eligible to the same office for the immediately following year only."

The United States shall be divided into five geographical divisions and one Divisional Vice-President shall be elected from each such Division for a term of two years.

Those geographical divisions shall be known as New York and New England Division, Middle Eastern Division, Middle Western Division, Southern Division, Pacific Coast Division.

The Divisional Vice-Presidents shall not be eligible for immediate re-election to the same office.

Article IV, Section 5.—Third paragraph; revise so that it reads:

At each Annual Meeting of the Society shall elect four Directors at Large to serve for a term of two years.

Article VIII, Section 1 (d).—A Nominating Committee of five members shall be appointed by the President on or before the 15th of December of each year. This Committee shall consist of a Chairman who shall be a Past-President of the Society, and

four members not members of the Board of Directors. The Committee shall deliver to the Secretary in writing on or before the last Tuesday in January the names of its nominees for the various elective offices next falling vacant, with a written consent of each nominee.

Appointment of Technical Secretary

Upon recommendation of the Executive Committee, the Board of Directors at the 1926 Fall Meeting at Buffalo established the office of Technical Secretary and designated Mr. Spraragen as the first incumbent on a part-time basis. His principal duties will be to assist in building up the membership of the Society, officially represent the Society in various ways and assist Sections through preparing material for meetings. A special Advisory Committee was set up, with whom the Technical Secretary will consult on all matters involving the Society in public hearings, etc.

Publication of Training Courses for Welders

The preparation of training courses for welders (all processes) has been completed by subcommittees of the Educational Committee. The material has been put in shape for printing by Mr. J. C. Wright, Director of the Federal Board for Vocational Education.

The material has been ready for printing for some months but it has been delayed because of the matter of expense. There is the equivalent of about 325 printed pages of the JOURNAL, so that the problem of determining which of many alternatives would be the most effective and the most economical is not simple. The Executive Committee has given this matter a great deal of attention, and it is believed that a reasonably satisfactory plan has been developed which will involve a minimum net final cost to the Society and at the same time effect a wide distribution. It is hoped that these courses will all be in print within the next few months.

It is to be regretted that this work has been delayed so long, because its publication and wide distribution should be one of the best kinds of welding propaganda. The dispensing of this kind of information should be an important function of the Society and there should be ample financial support for an educational activity which is so worthy.

Standardization of Nomenclature, Definitions and Symbols

At the 1926 Fall Meeting, the Board of Directors authorized the appointment of a committee to undertake the standardization of nomenclature, definitions and symbols in the welding field. The following committee was appointed: Messrs. Crowe, Deppeler, W. B. Miller, Warner, Whittemore, Woofter and Owens, chairman.

Standardization of Shapes and Sizes of Glasses for Welders

The Executive Committee appointed a committee to determine whether or not there was a demand for a project of this kind. The committee was unable to arrive at a definite conclusion and was discharged. However, the matter was not dropped. The Technical Secretary was directed to obtain by means of a questionnaire, addressed to about 150 manufacturers, users and others, information which would indicate definitely whether the welding fraternity desires a standardization of this sort.

Specification for Welding of Steam Pressure Piping

The American Specifications Institute has requested our criticism of a proposed Specification for Welding Steam Pressure Piping. The Executive Committee appointed the following committee to revise this specification: Messrs. Deppeler, Miller, Fyke, Schenstrom, Bissell and Spraragen, chairman.

A.E.S.C. Sectional Committee on Pressure Piping

There has been established a Sectional Committee under A.E.S.C. procedure, sponsored by the A.S.M.E. to undertake the development of standards for pressure piping. The Society was invited to be represented, and Messrs. Schenstrom and Fyke have been designated.

Miscellaneous Appointments

Prof. Adams and Mr. Ewertz have been appointed representatives of the Society on the Advisory Board of the Association for the establishment of Museum of the Peaceful Arts.

Mr. S. W. Miller has been designated to represent the Society on the A.S.M.E. Board in the award of the Lincoln Prizes.

Future Policy

My presidential address dealt with the question of the future policy of the Society. I believe that this is the most important matter before us today, and I would recommend, therefore, that a special committee be appointed to study and report on this whole question.

If this committee agrees with the general ideas advanced and the recommendations made in that address, it is suggested that there first be established close cooperative relations with the other organizations interested in welding. Each of these organizations is best qualified to serve certain useful purposes and undertake certain activities. There should, however, be a definite understanding among them so that there will be a minimum of overlapping and friction with a maximum of effectiveness and economy to the industry which all are serving.

F. M. FARMER.

April, 1927.

LEHIGH CONDUCTS WELDING SYMPOSIUM

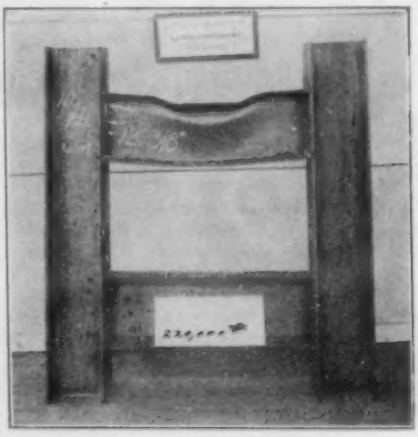
New Problems in Structural Fabrication Discussed at Well-Attended University Meeting

Several score members of the Lehigh Valley Engineers Club, in addition to practically the entire engineering student body, attended the sessions of the Welding Symposium held at Lehigh University, Bethlehem, Pa., Monday, April 4th. This meeting, which was planned and directed by a committee of which Prof. Ralph J. Fogg, head of the Department of Civil Engineering, was chairman, covered the matter of welding in construction and repair from many important angles. In an introductory discussion of the general subject, Prof. Bradley Stoughton described the various processes of welding and following this the physical characteristics of joints made by all of the various welding processes were demonstrated by testing of actual specimens at the Fritz Laboratory.

This testing, which was done in the presence of the audience, involved stressing welding coupons made by the oxy-acetylene, electric arc, electric resistance and thermit processes to destruction and plotting the results of these tests.

An outstanding feature of this work was the testing of a structure built up of two 10-inch H columns and two 12-inch I beams shown in the photograph. This was tested in compression, the failure coming as shown in the buckling of the web in the upper member. Stresses induced by this failure thrown into the weld caused final failure through the weld metal as expected.

In the frame test, load was applied to the upper member of a frame composed of two 10-in. H-columns and two 3-ft. lengths of 12-in. 31.8-lb. I-beam. The ends of the beams were not specially prepared for welding, but were simply cut square and butted against the columns and then welded. It was concluded after the tests that better results might have been obtained had the edges been chipped or beveled before welding. The maximum load carried was 220,000 lb., and failure occurred by buckling of the web of the upper beam under the load of the ram. Stiffeners had not been provided here



Welded Frame as Distorted in Test

because so high a load had not been expected. In the course of the failure, the joint at one end of the beam pulled away from the column at the top, the crack extending 7 in. down.

An afternoon session was devoted to demonstrations of welding by the various commercial methods.

At the evening session Prof. F. P. McKibben, formerly of Lehigh

Results of Tests Made at Morning Session of Welding Symposium Held at Fritz Engineering Laboratory, Lehigh University, April 4, 1927

Tension Tests

	Dimensions	Max. Load	Max. Unit Stress, Lb. Per Sq. In.	Remarks
First unwelded bar	⅞"x⅜"	20,500	62,500	
Second unwelded bar	⅞"x⅜"	20,300	62,000	
Gas welded bar	⅞"x⅜"	17,300	52,700	Broke at weld
Metal arc welded bar.....	⅞"x⅜"	17,570	53,500	Broke at weld
Carbon arc welded bar....	⅞"x⅜"	19,890	61,100	Broke at weld
Thermit welded bar	⅞"x⅜"	19,680	60,000	Broke at weld
Resistance butt welded bar	⅞"x⅜"	20,210	61,600	Broke 2" from weld
Resistance butt welded bar	⅞"x⅜"	20,920	63,780	Broke 4" from weld
Gas welded bar	⅞"x⅜"	17,950	54,860	Broke at weld

Bars machined after welding. Steel = .25 Carbon

Spot Welded Plates

2 ¼" spots .....1¾"x.167"	4,870	41,600	Broke at weld
3 ¼" spots ..... 2"x.045"	3,420	38,000	Broke at weld

Test of Welded Beam
(See Photo)
Max. Load 220,000 lb.

University and Union College, defined the present status of welding. Messrs. Lang and Smith of the Lincoln Electric Company, discussed the use of welding in structural steel work and A. F. Jensen of the Hannan Engineering Works, Chicago, read a prepared paper in rebuttal, entitled "This Is the Age of Riveted Steel." The discussion which followed these papers brought out many facts which emphasized the dependability of a properly designed and properly executed weld made by any of the various methods in commercial use.

SECTION ACTIVITIES

Boston

The April meeting of the Boston Section was held on the 21st. The speaker of the evening was A. G. Bissell of the Westinghouse Elec. & Mfg. Co., who presented a review of "Recent Applications of Structural Steel Welding," which was illustrated by lantern slides. The next meeting of this Section will be held on May 18, at which time the Boston Section will meet with the Lynn Section of the American Institute of Electrical Engineers. The subject for this meeting will be "Arc Welding."

Chicago

On May 12 the Chicago Section will hold the last meeting of the season. At this meeting S. W. Miller of the Union Carbide & Carbon Research Laboratories will give a discussion of the Design and Testing of Welded Steel Tanks and Other Pressure Vessels.

Philadelphia

The Philadelphia Section held its April meeting on the 18th. S. W. Miller of the Union Carbide & Carbon Research Laboratories presented a talk on "Fusion Welding of Large Vessels." The May meeting of this Section will be held on May 16. C. J. Holslag, manager, Electric Arc Welding & Cutting Co., will talk on "Welding of Houses and Buildings."

Pittsburgh

A very successful meeting of the Pittsburgh Section was held on April 15. A. M. Candy of the Westinghouse Elec. & Mfg. Co. gave a very interesting talk on "The Rational Design of Steel Structures for Arc Welding." The next meeting of this Section will be held on May 20. H. D. Kelley and W. R. Hulbert of the Metal & Thermit Corp. will present a complete review of the applications of thermit welding to heavy sections, pointing out the new developments in this field. The paper will be illustrated by lantern slides, motion pictures and demonstrations.

San Francisco

The Annual Meeting of the San Francisco Section was held on April

15. K. V. Laird, chairman of the Section's Research Committee on "Strength of Welds at High Temperatures," rendered a report on the results obtained by the committee and showed 15 to 20 slides of the specimens and equipment. The specimens of the welded pieces were exhibited.

The following officers were elected to serve for the coming year: Chairman, W. P. Brown, 223 Main Street, San Francisco; vice-chairman, R. H. Atkinson; treasurer and secretary, H. W. Saunders, Air Reduction Sales Co., Emeryville, Cal.; executive committee member, K. V. Laird, A. S. Lindstrom Co., 274 Brannan Street, San Francisco; Section representative, National Board of Directors, J. C. Bennett, Associated Oil Company.

Western New York Section

The April meeting of this Section was held jointly with the Engineering Society of Buffalo at the Hotel Statler on Tuesday evening, April 12. The principal speaker was R. L. Browne of the Metal & Thermit Corp., who gave a most interesting talk on the application of thermit welding in the various fields where it has proved most useful and economical. Mr. Browne's talk was copiously illustrated with lantern slides and also several reels of motion pictures showing in complete detail the application of the thermit process.

The principal welding applications described and illustrated were the welding of rails, the making of locomotive repairs, general repairs, particularly on heavy sections, marine repairs, etc.

J. H. Mallon of the Louisville Cement Co. gave an educational talk and an illustrated exhibit on masons' cements.

The report of the Nominating Committee was read and the following officers were nominated to serve for the year 1927-1928:

Chairman, Mark Wade of the Oxweld Acetylene Co.; vice-chairman, Edward S. Hebeler of the Allan Mfg. & Welding Co.; secretary and treasurer, G. W. Swan of Roebling's Sons Co.; Section representative, Robert Siemer of Allan Mfg. & Welding Co.; executive committee to serve for two years, C. H. Lockwood, General Electric Co.; J. H. Sander, American Radiator Co.; R. L. Kimber, Westinghouse Elec. & Mfg. Co.

The annual election will be held at the May meeting on May 17 at the Hotel Statler.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be addressed to the number indicated in each case and mailed to Society headquarters.*

SERVICES AVAILABLE

A-58. Welder desires position. Have had considerable experience in arc welding of pipes. Desire to secure position as structural arc welder or pipe welder. Can furnish references as to ability.

A-59. Have had 12 years' experience in welding of all metals. Desire position.

A-60. Foreman desires position. Am first class arc welder and employed at present in Puget Sound, Navy Department. Have had 2 years' supervisor experience over arc welders. Shop known for its "Quality Work." Graduated from Electrical Engineering Department, State College of Washington, 1914. In addition to mastering the practical details of the welding trade am familiar with welding design, metallurgy, arc-welding machinery and education of welders. Can furnish adequate references.

Oxyacetylene-Welded Construction of a Large High-Pressure Storage Tank*

By H. E. Rockefeller†, New York, N. Y.

The recent completion of a large ethylene storage tank, constructed for the Carbide and Carbon Chemicals Corporation, marks another decided step in the advancement of oxyacetylene welding in the pressure-vessel field. This tank, constructed of 1⅛-in. shell plate and 5 ft. in diameter by 43 ft. long, is now operating under the designed 300 lb. working pressure with complete satisfaction to the purchaser.

Before taking up a discussion of the design or method of welding this tank, it may be well to look backward a few years in order to indicate the gradual development of commercial welding in this field of application. About three years ago the Carbide and Carbon Chemicals Corporation was confronted with the problem of providing storage capacity for a gas at 125 lb. pressure, it being essential that the containers be *absolutely* leakproof. The advice of The Linde Air Products Company was solicited, and it being decided that the oxyacetylene process was the logical one to be used, the contract was placed with a tank fabricator with the understanding that Linde supervision be provided.

In the design and construction of these tanks, a definite procedure was worked out with the fabricator to insure satisfactory results. The factors involved in this procedure were: (*a*) correctly designing the joints, (*b*) selecting material of good welding quality, (*c*) determining the ability and knowledge of the welding operators, (*d*) properly preparing the plates for welding, (*e*) applying approved welding technique, and (*f*) testing the completed joints.

Since the fabricators had never welded plate as heavy as required in these tanks, it was agreed to limit the design fiber stress to 7000 lb. per sq. in. so that there would be no question as to the safety of the welded joints. On this basis of design a shell thickness of ¾ in. was required, the specifications calling for tanks 7 ft. in diameter and 35 ft. long. The results obtained on the first three tanks, however, convinced both the fabricator and the purchaser that the original design fiber stress was too low and it was consequently increased to 8000 lb. per sq. in. in designing the remainder of the tanks needed at that time. No discussion of the other factors involved will be made, as detailed consideration will be given to them in the subsequent description of the ethylene-tank construction.

In the early part of 1926 a demand arose for the storage of a considerable amount of gas at 300 lb. pressure. Although the tank requirements necessitated the use of heavier plate than had ever

*Presented at a joint meeting of the Metropolitan Section and Machine-Shop Practice Division of the A.S.M.E. with the New York Section of the American Welding Society, New York, January 4, 1927.

†Linde Air Products Company.

Cuts loaned through courtesy of *Mechanical Engineering*.

before been commercially gas welded in tank fabrication, the Carbide and Carbon Chemicals Corporation, having had such entire satisfaction in the operation of the tanks previously constructed, did not hesitate in specifying oxyacetylene welding.

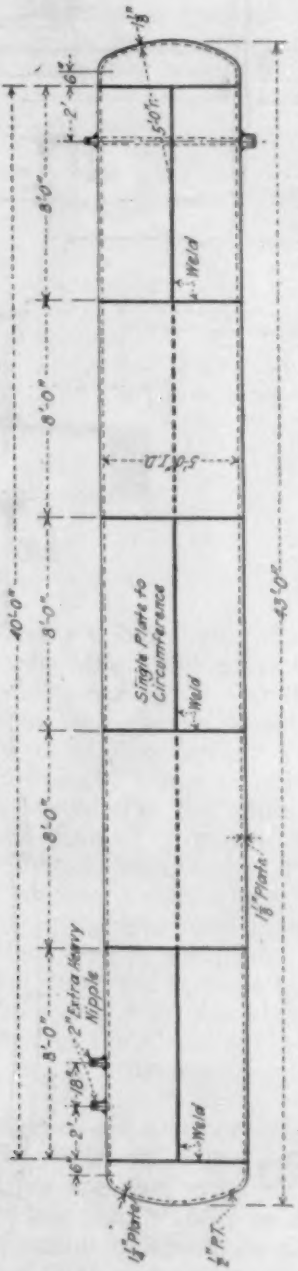


Fig. 1a. General design of high-pressure tank, five feet in diameter by forty feet long. See Fig. 1b for details.

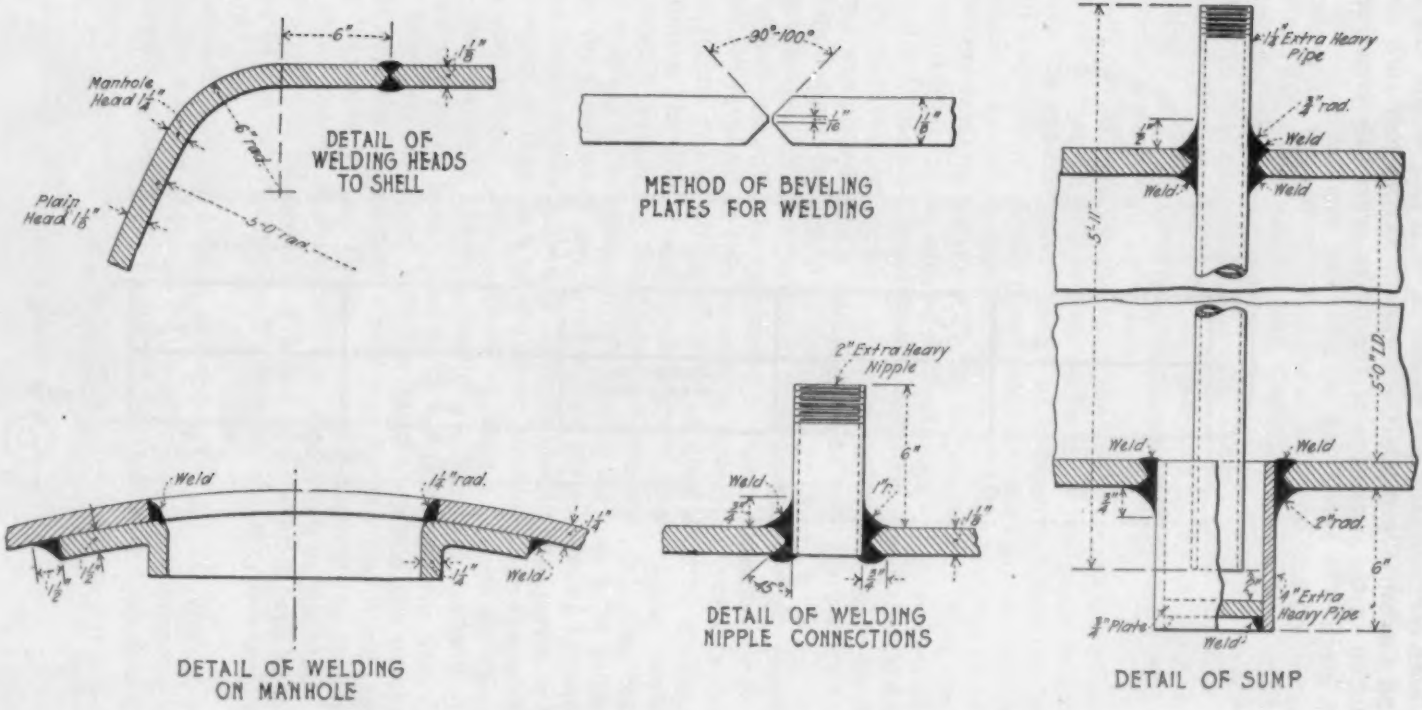


Fig. 1b. Details of construction of high-pressure tank shown in Fig. 1a.

Design of Tank

The storage requirements called for a tank 5 ft. in diameter by 43 ft. in length. The design is shown in Fig. 1a and 1b. The 1⅛-in. shell thickness was based on a design fiber stress of 8000 lb. per sq. in., the same as employed in the preceding construction. In designing the heads, however, several changes were made in the layout previously used. It had been found from

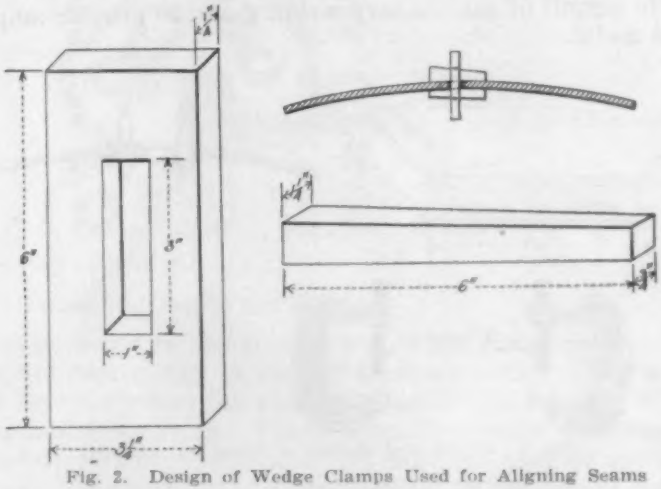


Fig. 2. Design of Wedge Clamps Used for Aligning Seams

strain-gage measurements taken during the tests of the last tanks that the metal exceeded the yield point on the head knuckles and about the manhole opening, a standard knuckle radius of about 2½ in. and a straight flange length of 3 in. having been used. To provide a more satisfactory knuckle design, a 6-in. outside radius and a straight flange or skirt 6 in. in length were specified. (It will be noted that the minimum inside knuckle radius by the A.S.M.E. Unfired Pressure Vessel Code would be 1.8 in.) Otherwise the heads were designed in accordance with the A.S.M.E. Unfired Pressure Vessel Code, except that a design stress of 9000 lb. per sq. in. was used instead of 10,000 lb. as is allowed on plate of the strength specified.

In an attempt to cut down the stresses about the manhole opening, the manhole reinforcing ring was also designed considerably stronger than specified in the Code, a 1½-in. saddle plate being used when one 1¼ in. in thickness would have met the Code requirements.

It will be noted that the design of the welded joints for all longitudinal and girth seams is of the double-V butt type. The included angle of V was specified to be not less than 90 deg. and the reinforcement not less than 3/16 in. on each side of the double-V, or a total reinforcement of about 30 per cent. The ultimate strength of this type of joint, when properly executed, considerably

exceeds the requirement of a factor of safety of five based on the comparatively low design fiber stress used in this instance.

The fillet welds joining the manhole reinforcing ring and manhead were so designed that their shearing and tensile strengths were greater than the tensile strength of the material removed from the head. (The unit shearing and tensile strengths of the weld metal were figured conservatively at 30,000 and 40,000 lb. per sq. in., respectively.) The welded connections were also designed to permit of satisfactory welding and to provide ample area of weld metal.

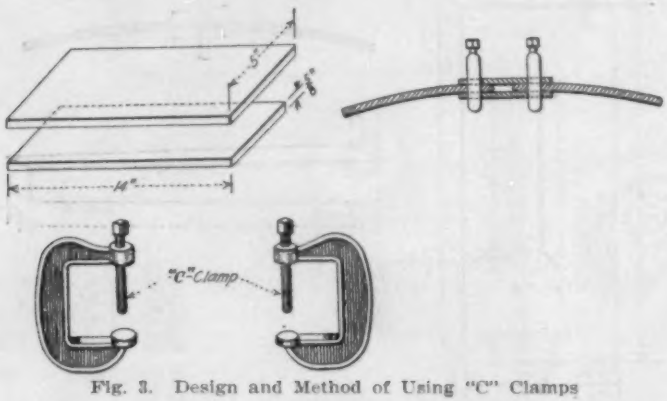


Fig. 3. Design and Method of Using "C" Clamps

Another point in the design which should be noted is the location of the welded seams. It will be observed that the longitudinal seams are staggered 180 deg. Where two longitudinal seams are used per course the seams should be staggered 90 deg., and when three seams per course are used, the angle-between adjoining welds should be 60 deg.

Selection of Material

In order to insure the quality of the material used, firebox steel with a maximum carbon content of 0.20 per cent and a minimum tensile strength of 50,000 lb. per sq. in. was specified. The specifications also called for the use of nickel-steel welding wire conforming to the American Welding Society specifications.

Check of the Welders

As a check on their ability to meet the welding specifications, each operator was required to pass a qualification test. The test included the welding together of two sections of 1⅛-in. plate, beveled and set up in accordance with the specifications. Three standard coupons were cut from each weld specimen and pulled in a tensile testing machine. The requirement for passing this qualification test was that none of the coupons should show an ultimate strength of less than 45,000 lb. per sq. in. of plate section.

None of the operators engaged in the plant at which the tank was

fabricated had ever welded plate above ¾ in. in thickness. With a small amount of practice under proper supervision, however, each of the welders easily passed the qualification test. The following table indicates the results of the tensile tests.

Welder	Specimen	Yield Point, Lb. per Sq. In.	Tensile Strength, Lb. per Sq. In.	Fracture
A	1	31,760	46,300	Edge of weld
A	2	35,000	54,400	In plate
A	3	36,200	53,300	In plate
B	1	30,600	47,600	In weld
B	2	35,420	54,200	In plate
B	3	35,400	53,500	In plate 1 in. from weld
C	1	33,000	50,700[1]	In plate
C	2	32,600	54,000	In plate 1½ in. from weld
C	3	31,200	50,200[1]	In plate 2 in. from weld
C	4	32,500	51,300	In weld

[1] Reinforcement ground off.

Preparation of the Parts for Welding

The steps taken in the fabrication of the plates preparatory to welding are noteworthy in view of their simplicity. The only laying out necessary was the placing of guide lines on the plate for beveling and resquaring. These operations were performed in a single set-up on the plate planer. To eliminate the flat spots on the plate ends, the edges of the plate were set to the proper curvature before being placed in the rolls. This operation was accomplished in a sectional press, the plate ends being heated before being formed. Although on the plate thicknesses previously welded the elimination of the flat spots had been accomplished by the use of jigs when lining up the girth seams, it was thought inadvisable to rely on this method of obtaining the proper curvature because of the stiffness of the heavy shell plate used in this instance.

Following the rolling operation, the abutting longitudinal seams were fastened by means of wedge clamps and then moved to the portion of the shop where the welding was to be done. The design of the wedge clamps employed is shown in Fig. 2. Prior to welding each of the longitudinal seams, one end was tack-welded and the other separated the required distance to provide for contraction. For tacking, a spacing of ⅛ in. was used, and a tack weld made about 1 in. in length. When necessary a turnbuckle was employed to obtain the desired spacing. The spacing of the seam for welding was secured by inserting a wedge at the open end and spreading the plate edges about two inches at this point. This provided an allowance for contraction during the welding of ¼ in. to the foot.

Welding Longitudinal Seams

In joining the longitudinal seams, the welding of the outer V was accomplished first, being carried on without interruption from

start to completion. Three operators alternated on two seams so as to provide a 15-minute rest period after each half-hour of welding.

The method of allowing for the contraction of the seam during welding proved entirely satisfactory. After the weld had progressed a short distance, the wedge clamps were removed and the contraction of the seam controlled by the use of a wedge and a

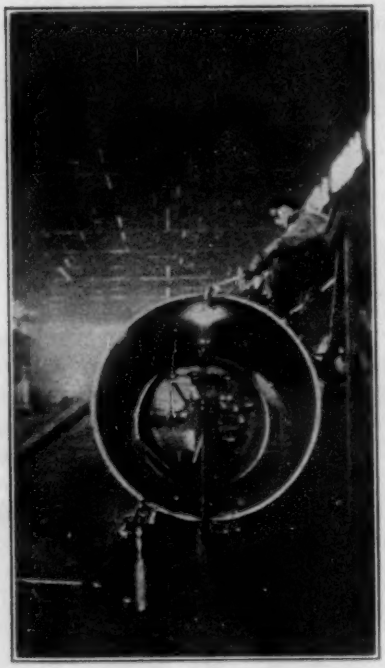


Fig. 4. Preheating Arrangement Tried in Preheating Out V of Longitudinal Seams. Note How Seam Was Tilted to Facilitate Building Up of Weld Reinforcement

Fig. 5: Method of Securing Desired Spacing and Alignment of Girth Seams. Note Tack Weld.

"C" clamp inserted at the open end of the seam. The manner in which the "C" clamp was employed is indicated in Fig. 3. The wedge was manipulated so as to maintain a spacing of about 5/16 in. between the plate edges a foot ahead of the point of welding. By doing this a constant spacing of about 1/16 in. was secured at the point of welding. This provided a sufficient opening to secure thorough penetration easily without slowing up the welding operation, as occurs when too wide a separation exists at the bottom of the V.

Preheating from the inside of the seam by the use of an oil torch was tried but soon discontinued. The improvised preheating arrangement, as shown in Fig. 4, was difficult to control and caused considerable discomfort to the welders. Therefore, when it was

discovered that the outer V could be welded without preheating, this supplementary operation was eliminated. The course, as will be noted in Fig. 4, was tilted at an angle of about 15 deg. to facilitate the building up of the required weld reinforcement.

After completing the seam from the outside, the inner V was chipped out to remove the oxide and excess metal which had penetrated to the inside of the seam without becoming thoroughly fused with the base metal. In welding the inner V it was found necessary to resort to preheating since the size of tip used, a No. 15 Oxweld, did not give sufficient heat to fuse the base metal with reasonable speed after the outer V weld had been made. An oil burner was used as the preheating medium, it being aligned in such a way as to direct the flame on the outside of the seam about 4 in. ahead of the point of welding. A forced draft supplied from the

Fig. 6. Preheating Girth Seam While Welding Inner V

shop compressed-air lines provided sufficient ventilation to carry off the heat radiating from the weld, making it possible to carry on the welding without interruption or inconvenience to the welders.

Reforming and Annealing

All the longitudinal seams were welded essentially in the manner indicated above. Upon completing the welding of the fifth course, they were checked for roundness and then annealed to eliminate any locked up stresses. Where necessary, the ends of the courses were heated and hammered to secure the required roundness. The annealing was accomplished by heating the entire length of the seam for a distance of about 1 ft. on each side of of the weld to a uniform dull red. The course was then removed from the fire, the heated section covered with dry ashes and the seam allowed to cool slowly.

These operations had not been employed on any of the tanks previously constructed as our experience had justified the decision that annealing of welded seams in general is unnecessary. In this

instance, however, these precautionary measures were taken because of the heavy plate used.

Lining Up and Tacking Girth Seams

The lining up of the girth seams was accomplished by the use of the same wedge clamps previously mentioned in connection with the lining up of the longitudinal seams and illustrated in Fig. 2. The courses to be joined were first set up on rollers and the adjoining longitudinally welded seams staggered as required. The wedge clamps were then inserted at equidistant points of about 8 in. along the entire seam. A spacing of ½ in. between the abutting plate edges was employed, and the wedge clamps manipulated until the seam was within ¼ in. of true alignment at all points on its circumference.

It was then tack-welded at four points. Two welders working at points 180 deg. apart, one on the top welding on the outer V and the other within the shell welding on the inner V, made two tack welds simultaneously. The shell was then turned through 90 deg. and the other two tack welds made. Each tack weld was about 4 in. in length and without reinforcement. Fig. 5 illustrates the manner in which the wedge clamps were used and the tack welds made.

Welding Girth Seams

The actual welding of the girth seams was accomplished in much the same manner as were the longitudinal seams. With the exception of one seam, the outer V was welded first without preheating and the inner V next, using the oil torch for preheating the seam from the outside. The manner in which the oil torch was used is indicated in Fig. 6.

Instead of tilting the course, as was done on the longitudinal seams to simplify the building up of the required reinforcement, the welding puddle was kept at an angle of from 10 to 15 deg. off center by turning the shell on the rollers as required. The welder, furthermore, instead of moving along the seams as it was welded, remained in one position and had the tank turned to suit his convenience.

The method of providing for contraction was also considerably different from that employed on the longitudinal seams. In the latter case, it will be recalled that the seam was spread at the open end and allowed to contract as the weld progressed. In setting up the girth seams, however, the abutting plate edges were spaced equidistantly along the entire seam and wedge clamps inserted at small intervals to retard the movement of the plate edges during welding. The four tack welds were made to prevent any undue contraction at one point and expansion at another.

It would appear that this method of providing for contraction by preventing it would tend to lock up the contraction stresses and thus give trouble. Since, however, a spacing of ½ in. was

provided before tacking, the weld was allowed to contract in small increments and the effect of this contraction was largely prevented from being transmitted to the unwelded portion of the seam because of the wedge clamps and tack welds used. This method therefore prevented the locked-up stresses from building up in such magnitude as to give any trouble. In welding the second side of the double V, furthermore, the locked-up stresses caused by welding the first side were largely dissipated through the reheating of the welded area both by the oil torch and the oxyacetylene blowpipe.

Fig. 7. Method of Maintaining Proper Spacing of Girth Seams During Welding of Outer V. Note Penetration Being Secured

The application of this method was carried on in the following manner. The wedge clamps were removed for a distance of about 18 in. from the starting point of the weld. As the weld progressed, other wedge clamps were removed in such a way as to maintain a spacing of about ¼ in., a foot ahead of the point of welding. To do this it was sometimes necessary to weld up to within about 4 in. of a wedge clamp before removing it, and the upright portion of the clamp, in this case acting as a wedge, had to be removed by cutting it out with the blowpipe. As the weld approached one of the tacks, however, the spacing between the plate edges naturally increased, and it was therefore a comparatively simple matter to control the contraction.

Following this method of procedure little difficulty was encountered in welding the six girth seams. At no point did the plate edges overlap, and for the greatest portion of the seams, the spacing between the plate edges varied from 1/16 to 3/16 in. Fig. 7 illustrates the manner in which the wedge clamps were used to maintain the proper spacing. The thorough penetration of the seam is also made clear in this view.

Welding Saddle Plate to Manhead

In welding the saddle plate to the manhead, the two pieces were first tack-welded at the four corners of the outer flange of

Fig. 8. Welding Saddle Plate to Manhead. Note Method of Preheating

the saddle plate. This was accomplished while the head was in a horizontal position and after the saddle plate had been properly aligned with respect to the hole in the manhead.

After tacking, the manhead was tilted at an angle of about 20 deg. and the welding started at a point adjacent to one of the tack welds. The oil torch was used to provide additional heat in the vicinity of the point being welded. The welding progressed until the second tack weld was reached. The head was then turned, the welding started in the opposite direction and continued until the seam was completed. This change in direction of welding was pursued in order to reduce the lock-up stresses and minimize the tendency of the saddle plate to lift up from the head.

The manner in which the seam was heated and welded is indicated in Fig. 8.

The seam having been completed from the inside, the head was turned over and the outside weld made. This seam was welded continuously in one direction, but otherwise the procedure followed was the same as employed on the inner seam.

Providing Ventilation

The sequence followed in joining of the shell sections and the heads was such as to entail the minimum discomfort to the welders.

It had been learned from previous experience in fabricating welded tanks, that as long as the cylindrical portion remained open at both ends, no trouble was encountered in keeping the welder cool and providing ample ventilation. In welding the inner V of the head seams and particularly in making the last inner V weld, however, even with the best ventilation system which could be provided with the available equipment, the welders had been subject to some discomfort from the heat. In the construction of the ethylene tank, therefore, it was decided to weld three courses together and then to join the heads to the remaining courses before attaching them

Fig. 9. Fracture at Manhole Opening. Note Solidity of Weld Metal and Fusion of Saddle Plate to Manhole

to the shell. This sequence worked out very satisfactorily with the improved ventilation system we were able to employ.

In welding the last seam, furthermore, contrary to the usual practice, the inner V weld was made first. This permitted the elimination of preheating when welding on the inside of the tank and also allowed part of the radiated heat to escape through the unwelded portion of the seam. The welding of the outer V of this seam was accomplished by the use of two welding blowpipes, one used as the preheating medium and the second for welding.

The welding of the nipples and other connections was carried on in accordance with regular accepted practice. Because of the considerable difference in thickness between the shell plate and pipe walls, however, the plate had to be preheated to a bright red before the blowpipe flame was allowed to impinge on the surface of the connection being welded.

Test of Tank

On completion of the tank it was first given the regular hydrostatic test imposed on all welded pressure vessels previously constructed. This consisted in applying a pressure of 600 lb. (twice the designed working pressure) and hammering all the welded seams with a 10-lb. sledge. The pressure was then increased to 900 lb. (three times the designed working pressure). This is the limit to which all previously constructed tanks were tested and is the test which is called for on welded vessels in the A.S.M.E. Unfired Pressure Vessel Code. (It might be pointed out here that since the A.S.M.E. Unfired Pressure Vessel Code allows a design fiber stress of only 5600 lb. per sq. in., the fiber stress under the required test pressure would be only 16,800 lb.

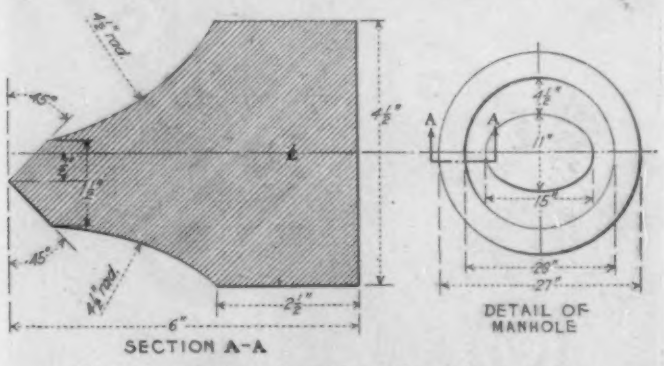


Fig. 10. Sketch of New Manhole Reinforcing Ring

per sq. in. On the ethylene tank, the fiber stress at the test pressure was 24,000 lb. per sq. in., or about 50 per cent greater than called for in the Code.) Having come to the conclusion, during the construction of this tank, however, that the 8000 lb. per sq. in. design fiber stress was too low for future construction, the pressure was further increased to 1000 lb., or the equivalent of three times the working pressure based on a design fiber stress of 9000 lb. per sq. in.

During these tests strain-gage measurements were taken at various points on the tank. These measurements, which have been analyzed in a detailed report prepared by Mr. T. W. Greene, indicated high stresses around the head knuckles and manhole, particularly about the latter. The tank therefore was again tested to 1000 lb. pressure to determine if there would be any increase in the permanent set at these points. The second test showed no evidence of distortion except in the metal about the manhole where there was a considerable increase in the permanent set.

The continuous yielding of the metal about the manhole at the 1000-lb. test pressure indicated a point of danger in the tank, and it was therefore decided to continue the test until no further permanent set occurred at the test pressure, or, if need be, to de-

struction. At 930 lb. pressure the tank failed through the manhole on the third application of the test pressure. Fig. 9 illustrates the manner in which the manhead failure occurred.

An examination of the head proved conclusively that the welds were in no way responsible for the failure as they were all intact except as severed cross-sectionally together with the saddle plate and manhead. On the other hand, this failure proved much in

Fig. 11. End of Tank Showing New Manhole Reinforcing Ring Welded in Position

favor of the welded joint, the manhead girth weld and the longitudinal weld in the course adjacent to the manhead being in no way affected.

Design of New Manhole Reinforcing Ring

In the repair of this tank it was only necessary to remove the defective head and reweld a new manhead, having in it a manhole reinforcing ring of the requisite strength. The design of the new reinforcing ring, a sketch of which is shown in Fig. 10, was developed by our own engineering department. Because of the high test pressure to which the tank was to be subjected, a cover plate designed for a working pressure of 450 lb. per sq. in. was specified. The basis for this design and subsequent alterations in head design are covered in a paper written by Mr. A. B. Kinzel.

The new manhole reinforcing ring was produced from a steel

slab, having the same chemical and physical properties specified for the shell plate. The slab was first cut by means of an oxyacetylene blowpipe to circular shape and then machined as required to produce the desired fillet and welding bevel. The elliptical manhole was cut out by means of an oxyacetylene blowpipe and the edges of the opening ground smooth.

The new manhead was constructed in accordance with our previous design, except that an 8-in. flange was specified to replace the metal removed from the first course in cutting off the defective head. After the head had been formed, however, it was necessary to remove a larger section from it than had been done on the previous head as the new manhole reinforcing ring was designed for butt welding to the head rather than lap welding as had been employed in the previous construction.

Welding New Manhole Reinforcing Ring to Manhead

The reinforcing ring was first set up and leveled at approximately the height required for attaching it to the manhead. The manhead was then lowered into position and after being blocked up to provide for a draft during preheating, was shimmed as required to bring the abutting edges of the reinforcing ring and manhead into alignment.

Four tack welds were next made at equidistant points on the seam, each two being made simultaneously at points 180 deg. apart. These tack welds were about 4 in. in length and without reinforcement.

After the tack welds had cooled, a firebrick preheating furnace was built about the entire head. This furnace was constructed in such a way as to provide the great amount of heat at the seam to be welded and in the heavy section of the manhole reinforcing ring. A natural draft was provided, entering through the openings between the blocks on which the head was set up and leaving through the elliptical opening in the reinforcing ring. Charcoal was used as the preheating medium, being distributed within the furnace through the elliptical opening. Asbestos paper was employed to cover the exposed section of the head.

Preheating was carried on until the manhole reinforcing ring and head in the vicinity of the weld had been brought up to a dull red. Welding was then started, using a long-handled blowpipe to keep the welder away from the heat.

After completing the weld from one side, all openings in the furnace were shut off and the head allowed to cool slowly and uniformly to room temperature. The excess metal was then chipped from the inner V as had been done on all other seams. Following this operation the head was set up for welding the inner V. It was then again preheated and welded. In order to eliminate any locked-up stresses, the head was completely annealed by placing it in a forge fire, bringing it up to an even heat and allowing it to cool slowly and uniformly.

Rewelding Manhead to Shell

The new manhead was welded to the shell by the same method as employed on the last girth seam previous to the head failure. A forced draft was maintained against the head, however, when welding the inner V, to carry away the heat generated and maintain a low enough temperature to permit entrance to and emergence from the tank through the manhole. Figs. 11 and 12 show the new manhole reinforcing ring welded into the manhead and a general view of the completed tank.

Retest of Tank

The rewelding of the manhead girth seam having been completed, the tank was again subjected to the same tests previously

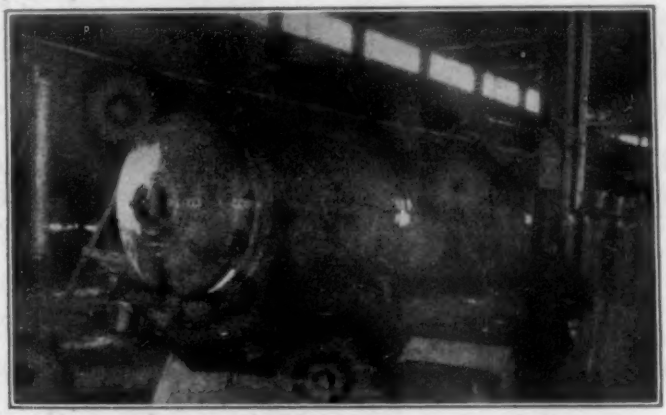


Fig. 12. General View of Tank Taken During Final Test

indicated. Following the initial test in which the head adjusted itself somewhat to the theoretical elliptical shape, a reapplication of the pressure indicated that the stress in the head and manhole very closely approximated the design fiber stress. The tank was therefore accepted as safe.

A secondary test for gas tightness was next applied, the tank being subjected to an air pressure of 450 lb. per sq. in. Under this pressure all the welded seams were tested with soapy water, but not a single leak was discovered. The tank was therefore accepted and shipped to the customer.

Summary

In the foregoing discussion the author has attempted to describe how the procedure involved in the construction of welded pressure vessels built under his company's supervision has been controlled; how with respect to the last tank constructed, the welders were carefully checked before being allowed to weld on the tank and supervised thereafter to insure uniformity of performance throughout the work; how material of proper welding quality was

specified and how this material was prepared for welding; how the welded joints, although designed on a fiber stress far exceeding that permitted by the A.S.M.E. Unfired Pressure Vessel Code withstood a test pressure which caused failure through a manhole saddle plate and head that had been based on a design previously considered safe for all types of construction and sanctioned by that Code; how when this point of weakness was discovered, a new manhole reinforcing ring was developed, and finally how under test the tank containing this reinforcing ring proved satisfactory.

No one will, the author believes, take issue with the statement that this tank is perfectly safe for operation under the designed working pressure. Welded-tank construction carried on under our observation since the completion of this tank has furthermore proved that the results obtained may readily be duplicated even when using a design fiber stress of 9000 lb. per sq. in. From their knowledge about the performance of small tanks, the author's company had convinced themselves that a much higher fiber stress could be used than had been recommended in current codes. When the problem of constructing large pressure vessels was presented, a gradual development was made, and by controlling the factors involved, it has been proved that size had no effect on the results obtained.

In the plant at which the tank under consideration was constructed, the welding of large pressure vessels has become a part of the regular production work. Procedure control methods have been thoroughly installed and this fabricator is now in a sound position to carry on welded-pressure-vessel work. Nor has the procedure adopted involved any regulations which would not be practical for any shop to adopt.

Many others interested in welding have come to the realization that uniformly successful results may be obtained in welded construction by the control of the factors involved, and as the development work carried on in this direction during the past few years is more generally appreciated, it is only logical to assume that engineering bodies and purchasers of pressure vessels will modify their ideas to permit a more liberal use of the inherent strength of welded joints.

The Design of Dished and Flanged Pressure Vessel Heads*—Abstract

A. B. KINZEL†

Recent experience has shown that for modern high pressure vessels the requirements in the present A. S. M. E. Pressure Vessel Code are not completely satisfactory. This article presents what are believed to be rational methods of design of heads. Consider first the shape of the head. In practice it is usual to design the crown of the head with the radius equal to the diameter of the shell and to use a knuckle of comparatively short radius. This gives an abrupt change in the radius of curvature and high bending stresses result on application of internal pressure. The elastic limit of the material in the head may be exceeded and the head assume a new shape which approaches an ellipsoid. It has been variously shown that the ellipsoid is the rational shape for a head.

Assuming an ellipsoid at head of the same thickness as the shell theoretical analysis shows that the maximum stress in the head is no greater than the hoop stress in the shell provided that the depth of the head is at least one-half of the radius of the shell, i.e., the semi-minor axis of the ellipse is at least one-half of the semi-major axis of the ellipse.

In the case where the head carries a manhole as in any other member which contains a hole and is subjected to strain, the stresses at the edge of the hole are much greater than they would be in a continuous plate. In the case of a freely supported infinitely large flat circular plate with a finite hole and normal pressure, the fiber stress at the edge of the hole is twice as great as in the rest of the plate. The logical way to take care of these stresses is by reinforcement at the manhole. This reinforcement should be so placed that minimum bending moments result.

This is accomplished by reinforcing with an inserted cylinder symmetrically placed with respect to the center line of the head. In computing the dimensions of this cylinder it may be considered that the head exerts external tension upon it and Lame's formula for thick cylinders applies. Any length in accord with engineering judgment may be assumed and the curves shown in the original article give the thickness of the cylinder wall for given maximum fiber stress. With proper consideration of induced bending moments the results for circular cylinders may be applied to elliptical reinforcements.

Conclusions

In conclusion the author would state that experiments and calculations both in Europe and in this country show that:

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*Abstract of a paper presented at a joint meeting of the Metropolitan Section and Machine Shop Practice Division of the A.S.M.E. with the New York Section of the American Welding Society, New York, N. Y., January 4, 1927.

†Union Carbide & Carbon Research Laboratories, Inc.

1. The present method of designing pressure-vessel heads is subject to improvement.
2. The design herein described, namely, an ellipsoidal head with a ratio of axis of 2 to 1, is much more satisfactory.
3. The manhole flange symmetrically placed and calculated as a hollow cylinder is also much more satisfactory.

Welding of Aluminum Sheets Used in the Construction of Pierce Arrow Bodies*

By Fred E. A. Klein† and Gust C. Hoff†

The advantages of using the oxy-acetylene welding process in the construction of automobile bodies made of aluminum sheets are many.

We find it more advantageous to cut and *weld*, eliminating the use of extra large sheets for large sections of body, enabling the use of small pieces in building the different sections and principally eliminating the necessary amount of drawing and stretching of the material over various shapes, sometimes bringing about the manufacture of very difficult shapes, necessitating expensive tools and heavy expenditures in labor and material when not cut and welded.

Welding is the joining together of two metal parts by uniform fusion at the line of contact. In order to secure a perfect weld it is necessary that each part is melted and the metal allowed to flow together and harden in this state of mixture.

In order that the welder may intelligently handle the work placed before him, he must be able to immediately establish the identity of the metals, recognize its properties, have a complete knowledge of its behavior under the welding flame and know exactly what treatment to give it.

This necessary knowledge cannot be acquired in any given time, but must be acquired by experience, careful observation and close examination of the work during welding.

The first property to be considered, being common to all metals, must be the melting point. The melting point of aluminum is 1215 deg. Fahr. The heat of the flame raises the temperature to this point and fusion or liquefaction of the metal occurs.

Aluminum does not melt gradually but takes on a pasty condition before becoming molten, and melts at approximately half the temperature required to melt steel.

The flame used when welding aluminum is practically the same as used when welding steel sheets of similar thickness.

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*Presented at Annual Meeting A. W. S., April, 1927.
†Pierce Arrow Motor Car Company.

Aluminum melts very fast and for this reason a small light blow pipe is used, being easily handled on work of this nature.

We use a No. 3 Tip to weld sheets 14 and 15 Gage and a No. 2 Tip to weld sheets ranging from 16 to 20 Gage in thickness. Acetylene gas with oxygen at approximately 3 to 5 lb. pressure gives a very good result. Both are best proportioned by the operator through experience.

When starting welds on thin sheets of aluminum a small filler rod should be used, this rod is usually made of narrow strips sheared from sheets or aluminum wire 98 per cent pure, 1/8 in. diameter.

The cut strips are most suitable and cheapest when used with proper tips and torch. By adequate provision made for the thermal expansion and contraction of the metals, together with the care, judgment and skill of the operator, very satisfactory results are obtained.

Immediately after the weld is made oxidation takes place and is the reaction produced by the combination of oxygen with a substance. This oxide must be removed and we use a flux for this purpose.

The flux and oxide remaining and having accumulated on the top of the weld must be removed. This is done by washing the surfaces of the weld and surrounding surfaces next to weld with warm water to stop corrosion and all surfaces finally steam cleaned. This is the best insurance to the removal of the oxide.

Another method used to remove oxide and flux from the surface of the weld is by scraping, but we find this is not practical on thin sheets, being more expensive than the other method described. All welded joints are hand hammered and finally filed to obtain the desired result.

The success of welding aluminum depends, to a great extent, upon the use of proper or suitable flux. Several makes are to be had, some of which are by far better than others.

It is also essential that the direction of the flame be horizontal, as a flame pointing directly down would blow holes through the sheet.

All our welds are known as butt-welding. This, we believe, is by far the easiest and most economical, eliminating the flanging so necessary in the weld called flange-welding, which gives very good results in the weld obtained, but requires labor to make the flange and additional material. Our experience tells us it is unsuited in our body manufacture, as the number of inches of surface to be welded on Pierce Arrow bodies varies with the different types, construction and sizes of these bodies, varying approximately from 110 in. to 400 in. of weld.

Every weld is hand hammered to insure solid material at weld. Hammering the weld after it is cold will make the metal harder and stronger although less ductile. Further, the action of hammering peens the surplus stock at weld into a smooth surface and

an even plane, best suited for the succeeding operations, such as filing and cleaning, also eliminating the trouble of having thin sections after filing due to the amount of material being necessarily removed to insure proper finished surfaces.

Every inch of body surface is hand filed and hand polished to insure the best possible condition suitable for final painting and finishing and obtaining the required finish so essential in the quality of Pierce Arrow bodies.

It is also necessary that the material used is of proper analysis and hardness.

Body sheet aluminum specified as 2-S-6 Gray Plate Half Hard is used throughout for the manufacture of Pierce Arrow bodies.

Because of its greater stiffness, half hard material is more easily handled in the shop, having less tendency to bend, buckle, dent and get out of shape. It is sufficiently ductile to permit rolling, flanging, bending, grooving and so forth.

Very often in the process of working half hard aluminum, it becomes hardened by cold working, such as forming and drawing by hammering. When necessary this can be annealed by moving a gas or gasoline flame over the surface to be softened until it is just hot enough to cause a piece of paper to leave a brown mark when rubbed against the metal. Care must be taken to heat uniformly and not to overheat, as overheating will induce grain growth with consequent brittleness. Material annealed in the above manner will have the properties corresponding to those of commercial soft annealed sheets.

The question of why weld and not solder is that no solder has ever been discovered which will give perfect results on aluminum under all conditions and for all classes of work.

We have done and still do some soldering of aluminum, but find it has not the strength or durability of welded aluminum, also it is more troublesome and less convenient. All of our bodies are made of aluminum and we do no soldering on body; all joints necessary are welded and hammered.

Expansion and Contraction of Welded Gas Lines

F. M. LEGE, JR.†

In laying welded large diameter gas lines, great care must be exercised to insure the lines are placed into the ditch under compression. To accomplish this, several methods of providing for slack in the line may be used.

The old method of wallops in the line is not as satisfactory as

†President Magnolia Gas Company.

it is with smaller pipe, as the large diameter lines are much stiffer, and an effective wallop hard to secure.

A sinuous line would be most satisfactory if it were possible to hold the line sinuous until it was lowered into a straight ditch and to prevent the slack so secured being shoved ahead of the line. Difficulty has also been found in laying large lines sinuous as the expansion caused by the heat of the sun during the day and the contraction caused by the lowered temperature during the night forces practically all the slack out of the line before it can be lowered into the ditch. I believe the most satisfactory method of securing and holding slack in large lines is that of distributing logs, blocks or other suitable objects every one hundred or two hundred feet, the distance depending upon the size of the blocks, and laying the line on top of same, thereby raising it from the ground twelve to twenty-four inches, relying upon the weight of the pipe between the blocks to hold the slack so placed in the line. The line may then be lowered into the ditch during the early forenoon, with skids distributed where the blocks were fomerly placed, after which it can be covered between the blocks, and the blocks removed during the night, to allow the line to settle into the ditch sufficiently to be covered. Unless the skids are placed across the ditch and the line is held up at regular intervals, the slack secured by use of the blocks will crawl ahead and will be lost for the purpose it was intended, and the line will have to be cut, as there will be more slack than can be placed in the ditch.

In East Texas, the temperature of a pipe line during the summer seldom exceeds eighty-five degrees Fahrenheit, and, in the winter, seldom goes lower than thirty-five degrees Fahrenheit. Therefore, the differential in temperature, which governs expansion and contraction, will seldom exceed fifty degrees Fahrenheit. Inasmuch as the expansion of steel pipe is .38 inch per 100 feet for each fifty degrees Fahrenheit, it will be necessary to provide not to exceed twenty inches per mile slack to take care of this factor, and only half that much if the line is laid while the temperature of the line is around sixty degrees Fahrenheit.

Where lines are laid during the summer, and the temperature of the pipe at the time it is lowered into the ditch is greater than eighty-five degrees Fahrenheit, there will, of course be a proportionately greater number of inches of slack to be provided for, due to the expansion. However, it must be remembered that the country traversed by a pipe line is seldom level, and practically all the necessary slack can be taken care of by crotching the line over all high points and ditching it deeply in the valleys.

Due consideration should also be given to the elasticity of the steel, and where the line crosses long, steep hills, great care should be taken to be sure that compression exists on both sides of the hill; otherwise, trouble may be experienced, due to the weight of the pipe causing a strain at the top of the hill.

The use of expansion joints or couplers, I think, is unnecessary and would only be a source of trouble. Our experience on many miles of both sixteen and eighteen inch pipe, that was laid under compression, shows that, with only a fairly good weld, no trouble will be experienced from expansion and contraction, with a variation of as much as sixty degrees temperature. On the other hand, where bad rod is used or poor welding is done, the least bit of contraction will cause the weld to crack.

Our experience with both long and short sleeve couplers convinces us that the couplings permit the line to crawl in very much the same manner as it does when laid sinuously, from the effects of the day's heat over the night's coolness. And, as a result, the pipe works beyond the elasticity of the rubbers in the couplers, which frequently causes leaks; whereas, with a line properly welded throughout and lowered under compression, both expansion and contraction are equally distributed over its entire length and give no trouble at all.

It is my opinion that the manner in which a large diameter welded gas line is placed in the ditch, with regard to compression, is of equal or greater importance than are good welds, as I am convinced that a poor weld will hold under compression when it would break on a tight line.

Have your ditch at least six inches wider than your pipe is thick, and at least twenty inches deeper than the thickness of the pipe, so that the pipe can seek its position without binding and lower it so it will be sinuous in the ditch and you will not experience any trouble, due to contraction.

In conclusion, I wish to state that we are not and do not contemplate using any expansion joints in either our oil or gas welded lines, regardless of size."

Selection of Materials for Welding*

E. E. THUM†

What with the ability of the oxy-acetylene flame to weld all of the common metals and alloys, we are liable to forget that only a few years back—say 20 years—the blacksmith had to select very carefully, indeed, the materials which he was to weld. He had to work with metal which would not be harmed by heating in his forge fire to a welding heat. Not only that, but his metal must be of such a character that it was malleable at a welding heat, and would not scale too rapidly while he was hammering it on the forge. Consequently he would insist on genuine wrought iron,

*Presented before Philadelphia Section, A. W. S., January, 1925.

†Union Carbide Sales Co.

which acted best in these respects. If he must, he would make a try at a very soft steel. But machine steel, tool steel, cast iron, brasses, aluminum and all the others which present no great difficulty to the oxy-acetylene welder, were of course entirely impossible to weld by crude blacksmithing methods.

This very ability of the oxy-acetylene flame to weld almost anything has obscured the fact that for good results in oxy-acetylene welding, as in wood-working, baking, tailoring or any other activity, it is necessary to select the raw materials on which you work. Of course the repair man cannot do this to the full extent. He must take what is brought to him, and do the best he can with it. He is able to select the welding rod and flux (all commercial acetylene and oxygen is of sufficient quality for his purposes) but the material which he joins is in general beyond his control.

With a manufacturer or shop owner who uses welding in production, however, the circumstances are different. He is and should be able to purchase metal especially for his welding operations. He does it in other lines. He buys tool steel for his tools—often two or three varieties for different duties; he buys a steel rod especially suited for screw machine work; he buys malleable iron for its toughness and machineability. Why, therefore, should he not buy steel on a "weldability" specification?

In fact, ample experience shows that if he does not, he will sooner or later get into trouble, simply because not all steel bar or plate has satisfactory welding qualities. It may look all right in the pile, but it may be of such a nature that it slows down production to a serious degree, if, indeed, satisfactory work can be done with it at all.

As an instance, I would like to cite an investigation made several years ago by Mr. C. E. MacQuigg of Carbon and Carbide Research Laboratories, for a manufacturer of welded tubing. Steel strip was being bent into a tube and the longitudinal seam welded in an automatic welding machine. A shipment of steel from the usual sources, apparently identical with former supplies, acted in an entirely different manner.

It was suggested that the welding flame was at fault, but this was disproved by making a series of tubes from mixed stock. The old steel (which might be called steel "A") produced a good tube, but each piece of the new steel (steel "B") fed into the machine immediately after a good tube had been made, and without any change in the adjustments whatever, made a tube with an irregular weld, having a slightly honeycombed or spongy surface in spots, and which would split in the weld when a tube was expanded or cupped.

Steels A and B were both good, as far as surface inspection could determine. The slight variations in color and appearance could easily be due to small variations in the annealing temperature and furnace conditions after the last draw.

Next the steels were analyzed for the usual elements. They

were both within two units, plus or minus, of the following composition:

Carbon	0.17 per cent
Manganese	0.40 per cent
Sulphur	0.03 per cent
Phosphorus	0.01 per cent
Silicon	0.03 per cent

No clue to the reason for a difference in welding behavior was found here.

Small samples of both steels were then polished for examination under the microscope. Steel A showed a considerably larger quantity of tiny specks (representing non-metallic inclusions, or holes from which such particles had dropped) than steel B, but still not enough to classify it as a "dirty" steel. Steels which weld well are usually clean; in this instance, however, the cleaner of the two acted poorly under the oxy-acetylene flame. After the polished specimens had been etched, so as to demark the boundaries of the crystalline grains, the microscope showed no observable difference in structure; both steels A and B appeared to have the normal appearance which would have been expected from the chemical composition and the method of manufacture.

Information can also be had by pickling a smoothed sample of the metal in strong hot acids. This often shows to the naked eye variations in structure from one region to another which are not easily found when comparing microscopic areas, or variations in chemical analysis which are not indicated in an average sample such as is furnished to the analytical chemist. Steel B was shown by this test to be quite definitely inferior to A. Long deep scratches were etched into the cross section of B (showing a so-called "Seamy" steel) and the outer surfaces showed areas where the acid had dug deeper than into the surrounding metal indicating clearly regions where sulphur or phosphorous or some other chemical element had been concentrated unduly.

A similar test was made on short pieces of the tubing which before pickling looked very similar. The acid used consisted of 3 parts sulphuric acid, one part hydrochloric acid and nine parts water. The samples were boiled in this for 20 minutes. Steel A gave uniform action along the length of the seam. On the other hand, the acid ate deep and irregular pits along the line of weld in steel B, suggesting the existence of gas pockets, uncovered by the acid attack.

It should be remembered that these welds were made without melting or without any filler or welding rod whatever—the abutting edges were merely heated and pressed together. Therefore the honeycombed appearance in Steel B indicated that there had been a considerable formation, evolution or trapping of gas in the weld at a temperature just below melting. To determine whether this gas existed in the metal itself the following test was devised:

Small strips were cut from both steels, shaped like an electric fuse (big at the ends and joined by a narrower strip). One by one, these strips were connected in a circuit carrying a high-amperage electric current. It heated fairly rapidly, and just as it sagged slightly and was on the verge of melting, the current was cut off, so the piece cooled and stiffened. In steel A the surface scale flaked off or melted and the edges of the strip merely rounded off. In steel B—it obviously was very gassy for it showed many pock marks where a bubble of gas forced its way up through the pasty metal, just on the verge of melting.

"But," it may be urged, "Steel B is of such a nature that the surrounding air causes these pock marks to appear." That objection has been met by other experimenters many times, first taking the precaution to cover the fuses with an enamel, properly applied, dried and baked. Then when the electric current is switched on the hot iron is covered with a viscous glass, impervious to the air. Steels of good weldability show no gas evolution, and are covered with smooth enamel at the end. Steels like B, however, evolve so much gas that bubbles the size of a pea form and burst through the glaze.

Perhaps enough has been said to indicate that some low carbon steels are not satisfactory for welding; that these steels boil with more or less violence when melted under the oxy-acetylene flame, throwing off a great many sparks at the time. The button when cold has a rough surface, pitted with numerous small craters. All of these undesirable manifestations seem to be due to gas or gas-forming compounds contained in the steel itself. It is impossible to discover such steel by chemistry, for it apparently has no relationship to the carbon, manganese, sulphur, phosphorous or silicon (the elements ordinarily reported in a steel analysis) and no means have yet been devised for determining accurately the gas content of the metal. Furthermore, it is not possible to measure gas or gas-forming compounds by microscopic examination.

Obviously, the simplest way to attack the problem is the right way. If a metal is unsuitable for welding it will boil and sparkle under the flame. Consequently the way to test for weldability is to melt the steel under a carefully adjusted neutral flame from a blowpipe tip properly chosen for size. A series of tests by J. H. Nead and R. L. Kenyon of the American Rolling Mills Company show that the results of this simple test agree in general with the indications of the electric fusion method, either of bare or enameled specimens.

A series of sheets of ingot iron, wrought iron, Bessemer steel and open-hearth steel (all below 0.10 per cent carbon) were tested in three different ways; namely, by electric fusion of bare coupons, by fusion under the oxy-acetylene flame, and electric fusion of enameled coupons. All three tests gave the same relative results. Four of them turned out to be good for welding, and three were

quite poor. Some variation in the arrangement of sheets as in the different classes was noted, but in general, either one of the three tests was able to differentiate between the suitable sheet and the unsuitable one.

The fusion test has been frequently recommended, especially for thin sheet metal. A recommended routine for making the test is as follows:

Take a piece of the steel to be tested about 4 in. square and place it on an iron surface but blocked above it so it does not touch. Melt the surface with a welding torch moving it along just fast enough to melt the steel. Use tip and gas pressures proper for welding the thickness of sheet being tested. Have a strictly neutral flame.

Under this treatment suitable steel will not "spit" or throw sparks, while in extreme cases of poor steel, the spitting may be so bad as to interrupt the flow of gases from the torch and cause it to backfire. Good steel will show a shiny smooth weld surface; poor steel will show a rougher matted surface. Good steel unites well with the sides of the weld, bad steel leaves grooves (or ridges) at the sides, or the bottom; good steel when melted enough to partly drop through, shows a clean smooth bead, free from sponginess or porosity, while poor steel shows the bead rough and black and in extreme cases badly honeycombed.

Poor steel will at times, as the above melting progresses, have holes blown in it, even though there is no change in rate of welding or other conditions. Good steel will not do this and it is difficult to force a hole through a small melted pool with the torch flame. This test is made by holding the torch tip vertically over the piece and leaving it there until a hole is blown through. This will occur quickly with poor steel but more slowly with good material. If the rounded surface at the edge of the hole is smooth and clean, the steel is good, while a rough, black, spongy appearance indicates poor material.

Good sheet has smooth beads, both top and bottom; the edges of the hole are round, and the globule of metal underneath is smooth and clean.

The bad sheet has very rough beads, both top and bottom, the edges of the hole are irregular, and the globule of metal underneath is rough and slaggy looking.

It should be emphasized, however, that this melting test is suitable only to steels of low carbon content. Mr. W. B. Miller, when at the Pfaulder Company, has shown that this test fails to indicate suitable welding material as the carbon content increases. He tested a series of steels as follows:

Steel D had 0.08 per cent carbon
Steel E was ingot iron, 0.01 per cent carbon
Steel L A contains 0.14 per cent carbon and was ¼ in. thick
Steel L B contains 0.20 per cent carbon and was ¼ in. thick

Steel L C contains 0.30 per cent carbon and was ¼ in. thick
Steel L D contains 0.14 per cent carbon and was ½ in. thick
Steel L E contains 0.24 per cent carbon and was ½ in. thick
Steel L F contains 0.28 per cent carbon and was ½ in. thick

A test which is suitable for low carbon sheet steel is not able to pick out a higher carbon steel ¼ in. and thicker. Of course, it would be wise to avoid steels containing as high as 0.30 per cent carbon for important work, but this is another part of the story. The point which should be emphasized here is that the fusion test is suitable for low carbon steels, but in my experience as the carbon content of the steel goes to 0.30 and higher, any steel will spark badly and boil under the oxy-acetylene flame, and work in general, like an unsuitable steel. This is one good reason for avoiding high carbon steels in welding work.

It is therefore recommended that steel which is intended for welding purposes should be purchased especially with that end in view. It is only necessary to specify when the order is placed that the steel furnished shall be of good weldable quality as determined by its action under the oxy-acetylene flame; then it will be necessary to test several samples from each shipment by merely melting an edge or corner and observing its general action. Ordinarily, this will not involve an extra price. On the other hand, if the purchaser were to specify chemical composition, tensile strength, hardness and several other physical properties as well as the ability to weld, all steel companies would quote a rather high price on the inquiry. For this reason, purchasers in many lines of industry have come to purchase their steel bar and plate under a rather indefinite specification that it shall be suitable for the purpose in mind.

In other words, if it must undergo considerable cold working as in pressing or stamping, the purchaser will specify that the steel must be suitable for pressing operations. If, on the other hand, surface finish is of paramount importance, the purchaser will specify that the steel must be suitable for enameling purposes if that is his business. "Screw stock" also demands no premium although it is bought primarily for easy machineability in automatic screw machines. This machineability is usually associated with high sulphur in the steel, but experience shows that if the specification calls for a certain percentage of sulphur, the steel company charges more money for it than if identically the same steel were furnished on a general specification as being suitable for screw machine work. Consequently, purchasers of steel for welding will ordinarily find little difficulty in getting deliveries from reputable concerns at no increase in price if they merely specify that the steel furnished them shall be of good weldable quality.

Welding Wire Investigations

The report given below was prepared by Chairman C. A. McCune of the Welding Wire Specifications Committee and was submitted to the members of the committee at a meeting held in Buffalo, November, 1926. Over 400 specimens were examined under the microscope, more than 300 mechanical analyses made and 20 or more welded specimens produced. Much time was also required in observing the behavior of the various specimens as well as in the applications of the "flame" test.

The Bureau invites discussion of this valuable report on the subject of "Welding Wire."

C. A. Adams, Director,
American Bureau of Welding.

Report to the Welding Wire Specification Committee

BY C. A. MCCUNE, Chairman

This is the first meeting of the reorganized Welding Wire Specifications Committee and it has been called at this time to determine in what manner, if any, the present specifications can be made more rigid so as to further guarantee that the welding wire purchased according to these specifications will be satisfactory.

Table Showing Chemical and Physical Properties of Wire Tested

Sample No.	Weldability		Chemical Analysis						Physical Properties		Remarks
	Gas	Elec.	C.	Mn.	P.	S.	Si.	Cu.	Tensile Str. #/sq. in.	Elongation %	
1	Good		.027	.12	.016	.031	.008	.094	61,700	5.8	
2	Poor		.04	.31	.008	.016	.006	.057	54,500	3.1	
3		H.Fair V. " O. "	.09	.40	.015	.021	.008	.145	79,800	1.6	
4		H.Fair V. " O. "	.13	.52	.021	.033	.004	.196	91,400	1.2	
5		H. " V. " O. "	.14	.52	.016	.031	.006	.196	98,700	1.2	
6		H.Poor V. " O. "	.12	.46	.013	.031	.006	.178	79,900	2.0	
7		H. " V. " O. "	.058	.14	.006	.029	.004	.084	57,300	6.4	
8		H. " V. " O. "	.08	.024	.006	.045	.003	.080	56,800	12.3	
9		H.Good V. " O.Fair	.027	.18	.017	.038	.004	.147	42,900	30.5	
10		H.Poor V. " O. "	.12	.31	.013	.036	.100	.063	83,600	19.4	Good with reversed polarity
11		H.Good V. " O. "	.18	.43	.010	.021	.147	.052	-	-	
12	Fair		.04	.18	.017	.025	.005	.084	54,100	6.0	
13	Good		.026	.06	.006	.044	.004	.020	58,900	2.1	
14	Good		.041	.37	.015	.047	.004	.042	69,900	2.4	
15	Good		.025	.091	.010	.030	.006	.060	86,500	2.5	
16	Poor		.05	.12	.009	.036	.005	.051	61,000	6.1	
17	Poor		.027		.046	.005	.006	.011	51,200	12.5	

H=Horizontal; V=Vertical; O=Overhead

Professor Adams, the director of the bureau, has asked that we accomplish something at this time to the extent at least of arranging a definite program of procedure.

Experience has shown to the industry that notwithstanding precautions outlined in the specifications it is possible to secure wire of quite varying qualities and with varying results therefrom.

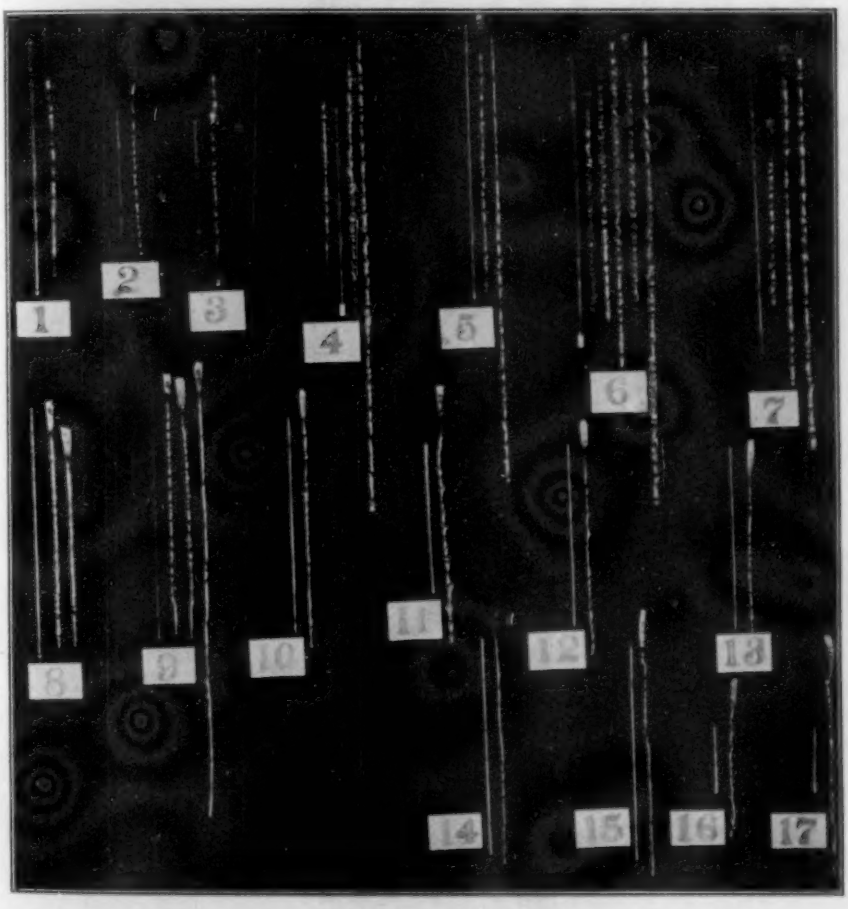


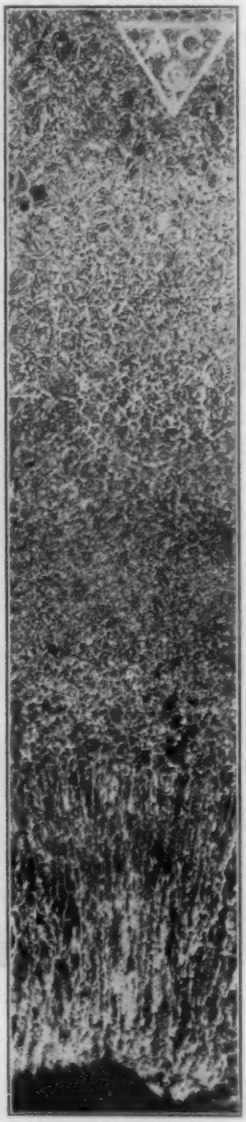
Fig. 1. Application of Flame Test

Industry, therefore, is looking to us to provide against this if possible. This applies to both gas welding wire and bare electrodes coming under the classification of G-1A, E-1A and E-1B.

In an attempt to secure some helpful data and to determine if it were possible to locate particularly detrimental elements in welding wire for this first meeting, I sent out a letter to the industries that are doing the greatest amount of welding, asking them to furnish us with samples of gas wire and electrodes found to be unsatisfactory. The result of this letter was that seventeen sets of samples

were secured with the statement that they were not good welding wire.

On checking this it was found that five of the seventeen samples



Changes in Structure Which Take Place in an Electrode

in the hands of an expert could be considered satisfactory for general welding.

Unfortunately, there was not a large amount of each sample,

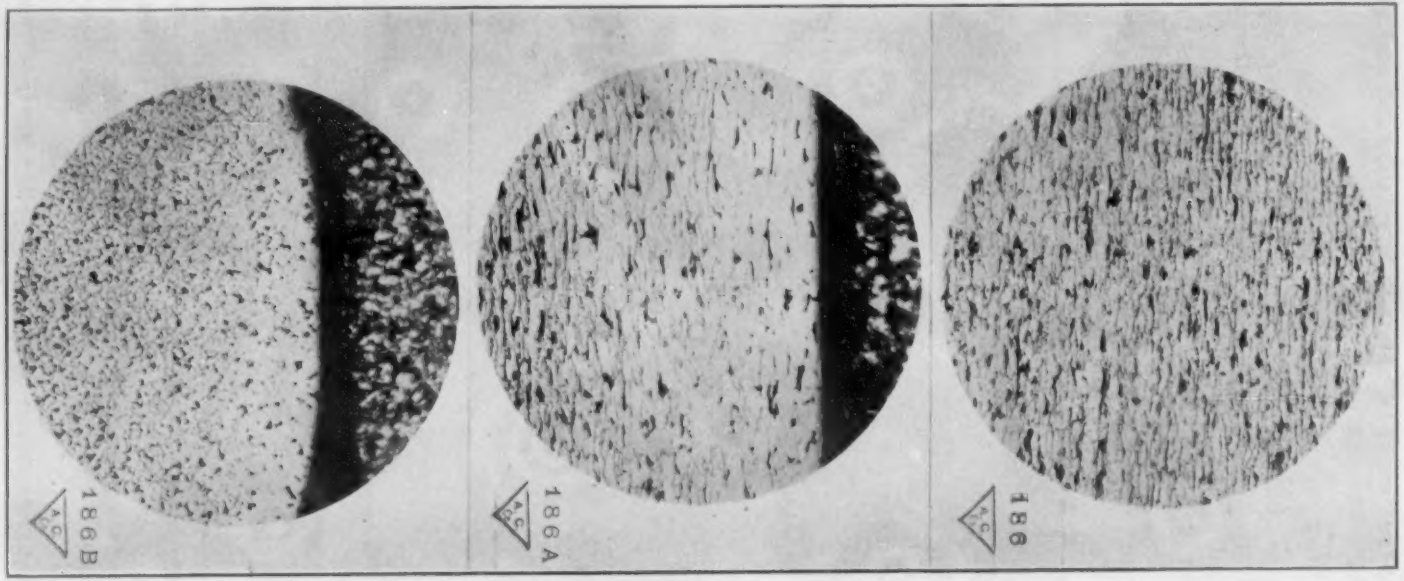


Fig. 3a. Transverse Surface

Fig. 3b. Longitudinal Surface

Fig. 3c. Longitudinal Center

Fig. 3a, 3b, 3c is 5/32 in. electric wire, 100 X (reduced to 2/3 size). Weldability fair in horizontal, vertical and overhead positions. Chemical analysis, C .13, Mn .52, P .021, S .033, Si .004, Cu .196. Physical properties—Tensile 91400 lbs., Elongation 1.2 per cent
Sample No. 4

but the results that could be obtained were recorded and are submitted for your consideration.

Gas Welding Wire

There are eight sets of photo-micrographs, including a six part chemical analysis, the carbon being determined by the combustion method and a very thorough checking of all elements. Also the physical properties of the wire are shown as well as the weldability.

The gas content of the wires was not determined due to lack of sample.

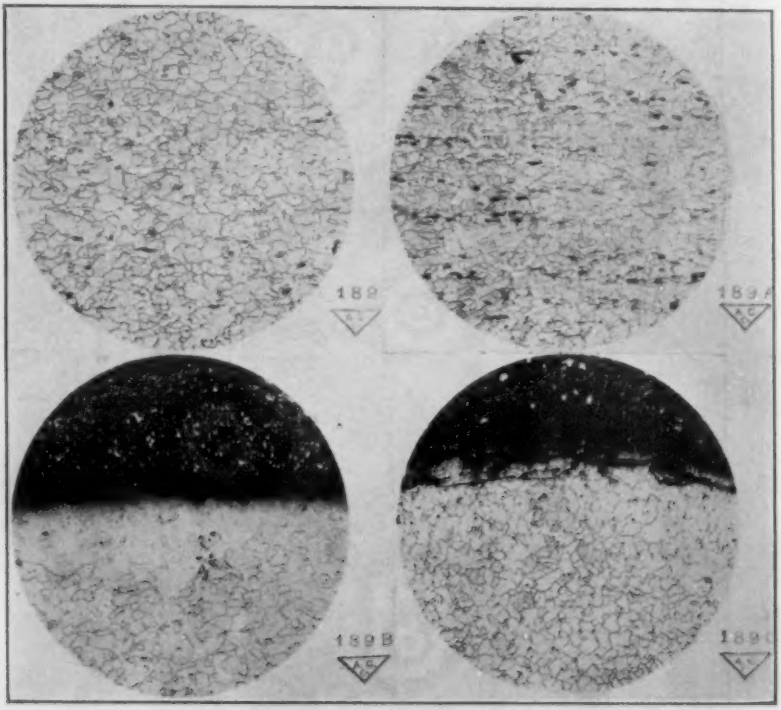


Fig. 4. 100×, reduced to half size, sample No. 7, 3/16 in. electric wire Upper left hand figure—longitudinal center; upper right hand figure—Longitudinal center; Lower left—longitudinal surface; lower right—Transverse surface. Weldability poor in horizontal, vertical and overhead positions. Chemical analysis, C .05, Mn .14, P .006, S .029, Si .004, Cu .084. Physical properties—Tensile 57,200 lbs., elongation 6.4 per cent

Fig. No. 1 shows the results of the application of the flame tests. This test is made by melting the wire half way through its diameter, using the oxy-acetylene torch. A very small tip was employed, the flame being positively neutral. The flame test apparently shows some of the things not revealed by other determinations.

In a few cases the uneven appearance of the surface resulting from the flame test was due to the unclean surface condition of the

Fig. 5a. Transverse Surface Fig. 5b. Longitudinal Surface Fig. 5c. Longitudinal Center

Fig. 5a, 5b, 5c, is 3/16 in. electric wire, 100 × (reduced to 2/3 size). Weldability poor in horizontal, vertical and overhead positions. Chemical analysis, C .03, Mn .026, P .005, S .045, Si .003, Cu .050. Physical properties—Tensile 56,800 lbs., elongation 12.3 per cent Sample No. 8

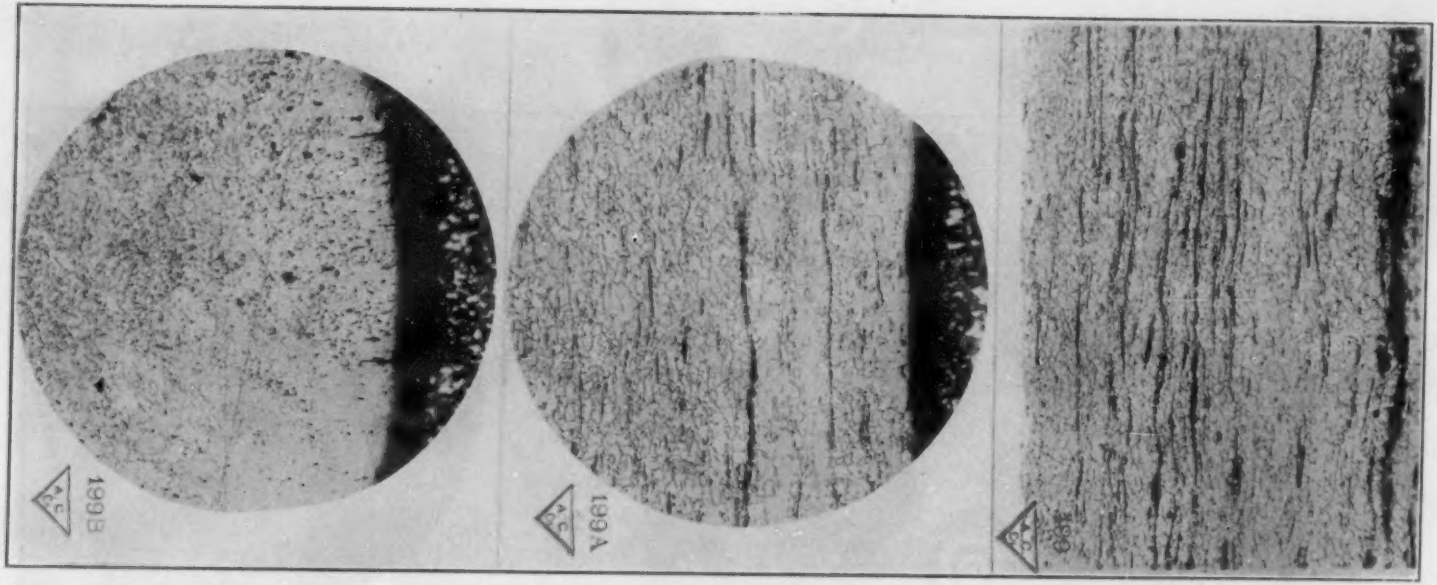


Fig. 6a. Transverse Surface

Fig. 6b. Longitudinal Surface

Fig. 6c. Longitudinal Center

Fig. 6a, 6b, 6c is ⅛ in. gas wire, 100× (reduced to 2/3 size). Weldability poor in horizontal, vertical and overhead positions. Chemical analysis, C .027, Mn very low, P .066, S .005, Si .006, Cu .011. Physical properties—Tensile 51,200 lbs., elongation 12.5 per cent
Sample No. 17

wire, but in the majority of cases the occluded gases and non-metallic inclusions were directly responsible.

Electrodes

The same work was performed on the electrodes as on gas wire with the results as shown.

Some of the wires have apparently received some sort of heat treatment after drawing whether intentional or otherwise, while others show only the effects of cold work or no special treatment. The weldability was just as varied as the structure.

A sample weld made from No. 8 wire is also submitted. It was very difficult to hold a steady arc even in the hands of an expert.

In connection with this work, Dr. Andren, who has been following the metallurgical study of these specimens in our laboratory for us has been successful in photographing the changes which take place in the structure of an electrode, Fig. 2. This, I believe, is the first time this has been done and is submitted for your observation. I am quite sure you will find it interesting.

The work which I am submitting here has taken quite a little time to accomplish and I believe indicates the further extent of investigation that welding wire may be subjected to, and if all this work only opens the door leading to further investigations and more complete study, I feel much will have been accomplished by this evidence.

Cutting Metals Under-Water*

L. F. HAGGLUND†

With the advent of steel vessels, the need for a reliable underwater metal cutting torch originated. For many years, however, the demand for such a tool was so limited that practically nothing was done to solve the problem of cutting steel and various other metals under water until the period of the World War.

From 1914 to 1918, the demand for ships increased rapidly and along with this the damage caused by hostile submarines, mines, congested harbor conditions and inexperienced ship officers resulted in numerous wrecks of steel hulls. These wrecks brought a greater volume of business than ever before to the marine salvage companies. This encouraged the use of new and better methods and one of the immediate results was the development of a practical and reliable method of cutting metal under water.

On April 25, 1918, the S.S. "St. Paul" capsized and sunk alongside her pier in New York Harbor. The work of righting and raising the S.S. "St. Paul" presented one of the largest and most difficult problems that modern marine salvage had ever had to meet. During the work it became necessary to cut numerous

*Presented at the February meeting of the New York Section, A. W. S.
†Manager, Under-Water Metal Cutting Corp.

drainage holes between various compartments of the "St. Paul." With the then known methods, i.e., drill, hacksaw and chisel, this work was extremely slow and efforts were made to find some way in which to expedite this phase of the work.

The idea of cutting these holes under-water by electricity occurred to one of the men engaged on this part of the work. It was tried out, and when the electric arc was combined with a jet of

Fig. 1. Oxy-Electric Under-Water Metal Cutting Torch

oxygen, a clean cut was obtained in the submerged steel plate. Accordingly, the two men engaged in this experimental work, R. E. Chapman and John W. Kirk, took out a patent on the method of cutting metals under-water by means of the electric arc and oxygen. The method was then used successfully to cut the remaining drainage holes on the vessel and it was raised.

This method combines the heat of the electric arc, together with

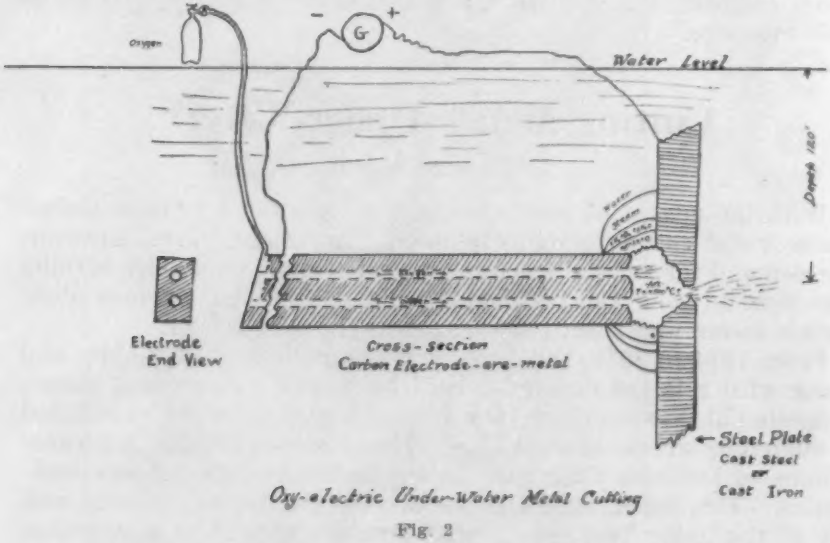
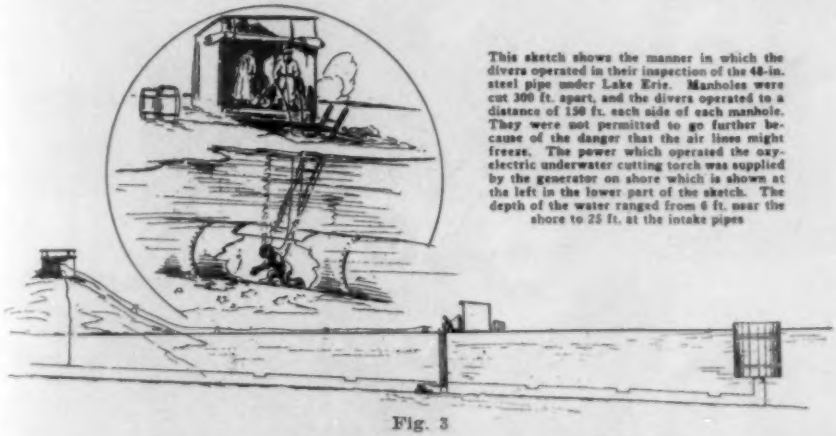


Fig. 2

the oxidizing effect of a stream of gaseous oxygen. The electric arc can be drawn under-water as well as on the surface, and the electric circuit is similar to that used in electric welding. A hollow carbon electrode is used and the oxygen forced through this electrode under pressure is directed onto the molten metal where the arc is acting. The oxygen serves two purposes. It completely oxidizes part of the metal, and in addition it tends to blow the

molten metal out of the cut, thereby preventing the rapid solidification of the metal as such due to the cooling effect of the surrounding water.

This torch operates in the water and is not protected by a cup or cone of compressed air. In salt water, however, the electrode must be insulated to prevent a loss of current due to electrolysis, and the tip alone is left exposed. In fresh water the same insulation is used, but in this case it only serves to prevent arcing from



This sketch shows the manner in which the divers operated in their inspection of the 48-in. steel pipe under Lake Erie. Manholes were cut 300 ft. apart, and the divers operated to a distance of 150 ft. each side of each manhole. They were not permitted to go further because of the danger that the air lines might freeze. The power which operated the oxy-electric underwater cutting torch was supplied by the generator on shore which is shown at the left in the lower part of the sketch. The depth of the water ranged from 6 ft. near the shore to 25 ft. at the intake pipes

Fig. 3

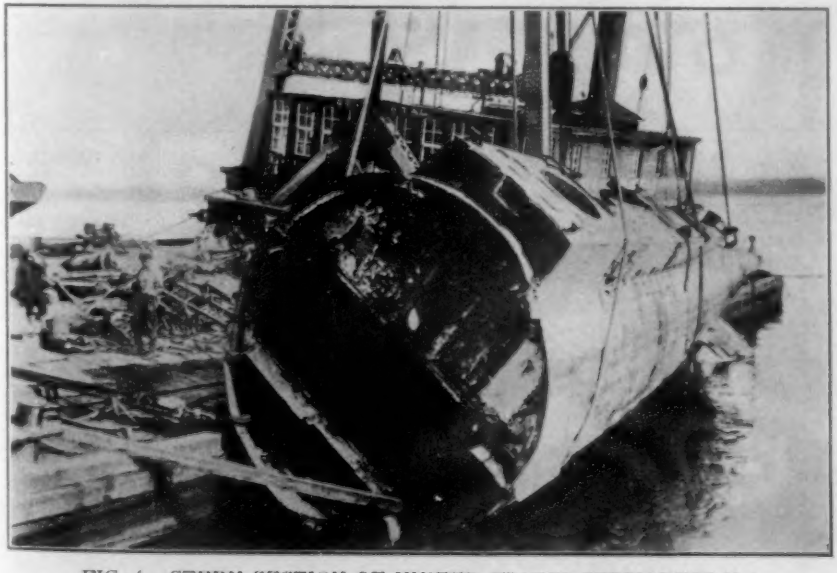


FIG. 4. STERN SECTION OF UNITED STATES SUBMARINE N-4

The U. S. Submarine N-4 was sold to be scrapped. Shortly after the work of dismantling had started the N-4 sank at a wharf at Bridesburg on the Delaware.

Various methods of raising the submarine were considered. In all of these the weight of the submarine (240 tons), and the hoisting capacity (85 tons) of the largest floating derrick in Philadelphia entered.

Finally it was decided to cut this submarine into three sections of equal weight under water and then raise each section separately by derrick.

The photograph shows the stern section of the N-4 brought to the surface.

The cut at the forward end of this section was made by divers working at a depth of twenty-five feet with the aid of an oxy-electric under-water metal cutting torch.

the side of the electrode instead of from the tip where the oxygen jet is located.

Although this oxy-electric torch operates in the water without any apparent protection, what actually happens is that the water immediately adjacent to the arc is broken up into oxygen and hydrogen and as these two gases move away from the arc, they reunite with a series of small explosions to form water vapor, and as a

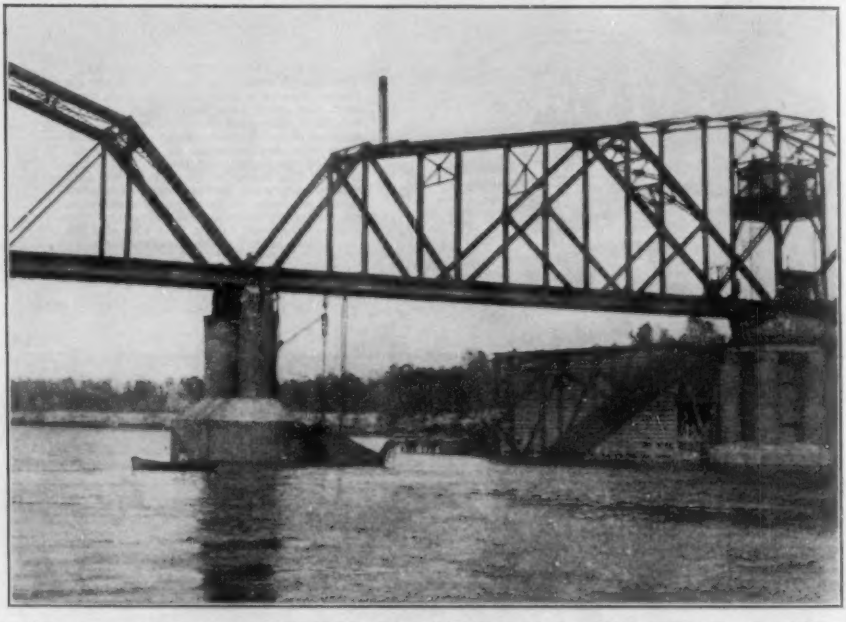


FIG. 5. TEXAS & PACIFIC RAILWAY DRAW SPAN, ATCHAFALAYA RIVER, MELVILLE, LA.

Showing removal of collapsed steel sheet wall of 33 interlocked piles from draw channel.

This section of piling was broken away from the bridge pier and bent down into the draw channel during flood season. It was removed by a cut along the original line of piling made by a diver in 25 feet of water.

result the arc is operating in a continuously forming cone of steam.

The accompanying sketches will serve to illustrate the electric circuit used, the manner in which the oxygen is combined with the arc and the action that takes place during the cutting operation under-water.

To date this method has been used successfully at various depths down to 120 ft. to cut steel plate, sheet piling, cast steel, cast iron, copper and brass. It has been used to effect the removal of collapsed steel pile cofferdams, to aid in patching and pumping operations while salvaging vessels, to remove and to repair sections of submerged pipe and to expedite cleaning by cutting manholes in long submerged pipe lines. The method has also been used to remove the wreck of a sunken submarine by cutting the hull into sections that could be raised by derrick.

The accompanying photographs will illustrate some of the various jobs that have been done with this method and apparatus.

The cut at the forward end of this section was made by divers working at a depth of twenty-five feet with the aid of an oxy-electric under-water metal cutting torch.

Seam Welding*

W. H. GIBB†

The term "seam welding" is applied to that process of resistance welding by which the overlapped edges of two pieces of sheet metal are joined in a continuous weld, without the addition of any other metal. This process is sometimes called line welding.

As a background for what is to follow, I shall review briefly the method or cycle used in making a resistance weld. The term "resistance welding" for practical purposes embraces butt welding, spot welding, and seam welding. We need not concern ourselves, however, with the butt welding operation in a consideration of the subject of seam welding, but since the seam welding operation was developed directly out of the spot welding operation, I shall briefly indicate the steps taken in producing a spot weld. The simple essentials of a spot welder are a transformer properly housed, having a secondary capable of carrying a heavy current without heating, an upper and a lower welding horn provided with suitable welding electrodes, preferably water cooled, and a means of applying pressure to the weld which is made between the welding electrodes. The welding cycle itself is simple. First, the sheets to be welded are placed between the electrodes, overlapping each other to such extent as the requirements of the work indicate. Sufficient pressure is then exerted to bring the sheets into contact with each other. The primary circuit of the welding transformer is closed, causing a high amperage welding current to flow in the secondary. The sheets are heated to a plastic state because of the resistance to the flow of current at the point of contact. The current is then switched off and a final welding pressure completes the cycle.

The conception of a seam welder, by one familiar with the spot welding operation, was a rather obvious step, and it was not long before the idea of making a continuous weld between two revolving electrodes or between a revolving electrode and mandrel or welding horn, with the work interposed, was conceived and given practical tests and application. It was shortly discovered that the old method of welding in the way that it was first conceived and used was applicable only to entirely clean metal. The attempt to weld any other than clean metal resulted in either leaks or burns. In addition to these difficulties the welding rolls became pitted and oxidized from the too high temperature so that they could not be used for further welding until cleaned, thus greatly retarding the operation and adding to its cost.

For some reason this particular field was practically neglected for a great many years. This was probably due to the difficulties mentioned which, no doubt, seemed almost insurmountable to the

*Presented at March, 1927, Meeting, New York Section, A. W. S.
†President, Gibb Welding Machines Co.

ous jobs that have been done with this method and apparatus.

pioneers in the field but it is safe to say that if this method of welding had had the intensive study and experimentation that was given to other branches of electric welding, progress would have been much more rapid. The actual fact is, however, that the process of seam welding remained at a stand-still for many years with only a few practical applications. Comparative inactivity in this line may be said to have continued up to the year 1921. At that time our company had an agent in Europe, whose duties on our behalf were to advise us of any developments in the welding field. Among other things, he sent us details of a machine brought out by a German manufacturer, known as a roll-step or step by step seam welder. We found these machines to very closely resemble, in appearance, the continuous seam welder up to that time in use, inasmuch as either two welding rolls were used or a welding roll and a mandrel. The machines differed, however, in the driving mechanism which consisted of an eccentric actuating a pawl and ratchet arrangement. By this means the driven welding roll moved periodically and the whole welding cycle was briefly this: as the welding roll came to rest on the seam, the current was automatically switched on causing the metal to be heated to a plastic state. Then the current was automatically switched off. The pressure of the water cooled welding rolls squeezed the material into a homogeneous union and tended to solidify the weld. The roll then moved a fraction of an inch to the next step. When the rolls came to rest the same welding cycle was repeated. It will be observed that during the time the rolls were in motion and when the work was moved between the rolls, there was no current flowing. Figure 1 is an example of this type of machine. The claim was made by the German manufacturer that these seam welders would weld ordinary commercial sheets without removing scale by pickling, grinding, or any other method. This claim was either a misrepresentation or a case of "over optimism" as you please. This type of machine, being in a sense an automatic spot welder, could successfully weld stock lacking something of being entirely clean but it was far from true that ordinary one-pass sheets could be welded.

This new method of welding was a distinct step in advance since it permitted of welding heavier gages than had heretofore been possible and extremely careful cleaning of the stock was not necessary.

I should like to make further comment on the matter of cleaning sheets, both as applied to the spot welding and seam welding operations. Anyone familiar with the spot welding operation will know that with the proper pressure and heat a single spot weld can be made successfully on one-pass material. This result is not always obtained and the weld is never so nice in appearance as on clean stock but in the practical application of the spot welder, a very considerable amount of scaled or dirty stock is welded. At the same time, experience proves that this is not a thoroughly prac-

tical production proposition; chiefly because frequent cleaning of the electrode points is necessary since the oxide of the sheet will imbed itself into the copper. The reason for this is that the contact between the copper and the top of the sheet is so imperfect, because of the oxide, that almost as much heat is created at this point as between the sheets. This brings the surface of the sheet to a semi-plastic state and also heats the copper. Therefore, it proves an easy matter for the particles of steel and oxide to unite with the copper under pressure. This is frequently augmented by the fact that the surface of the one-pass sheet is rough and considerable arcing is experienced, particularly after a few welds have been made. In other words, unless the points are cleaned practically with each weld, the sheet will be pitted or burned. The welds themselves will be of questionable value so far as strength is concerned, for the reason that the oxide is imprisoned in the weld, preventing a clean metal to metal union.

Reverting to the roll-step method of seam welding, it is obvious that the making of a series of spot welds, each overlapping the last so as to produce a continuous seam, could not be as rapid an operation as the older method of continuous welding. The advantage of the method did not, therefore, lie in an increased speed. On the contrary, speed was reduced. The advantages were that seams of any desired length within the limits of the machine could be made without the drawback inherent in the old type machines. The fact that heat does not accumulate in the roll-step method of welding, of course, lies in the fact that the current is interrupted at regular intervals. A fair average of speed for the roll-step machine would be about 150 ft. per hour. We produced seams on lighter stock at a rate as high as 180 feet per hour.

A study of the roll-step machine led to the development, by our own Engineering Department, of a type of machine somewhat on the same order but differing in that the welding rolls were never brought to a complete stop but were revolved alternately at a rapid speed and then very slowly. This was accomplished by means of elliptical gears in the mechanism actuating the welding rolls. This proved an entirely practical machine and slightly increased the speed of welding over that developed by the roll-step machine. It is characteristic of the rapid developments of seam welding in our own organization at the particular time that this new type, which we termed the "dual speed" seam welder was never put on the market; this for the reason that a further important development came right on the heels of our experiments with the dual speed machine. This development consisted of the discovery that the interruption of the current alone was equally effective in producing good welds, whether the work was stopped, slowed down, or run through continuously. The seam welding machines operating on the current interrupter principle (Fig. 2) are similar to the continuous seam welders in that the welding speed is high and no strain is put on the mechanism by the abrupt stopping and

starting of welding rolls. They combine with this also the features of the step-by-step method in that the current is interrupted rapidly. This permits a surge of welding current and a subsequent cooling period. To go back for a moment to the continuous seam welder, when the current is continuously applied and the work is subjected to welding pressure, the stock is frequently burned and pitted for reasons that have been mentioned. On the other hand, if the current is reduced to a value which will not injure the metal, the metal is frequently only sweated or insecurely stuck together. With a proper mechanism for interrupting or breaking the weld-

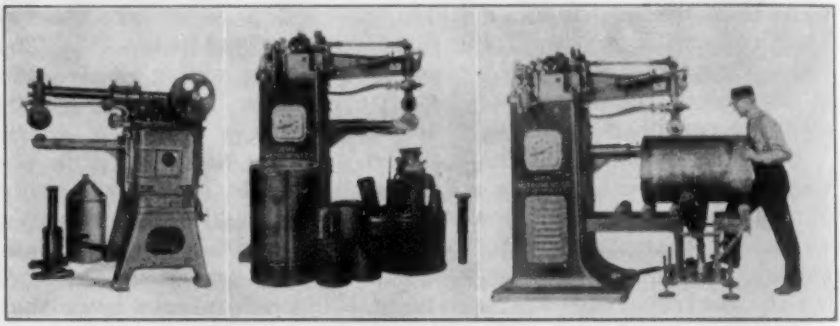


Fig. 1. Roll step seam welder

Fig. 2. Current interrupter seam welder

Fig. 3. Automatic seam welder, current interrupted

ing current, burning and pitting can be entirely eliminated and the welding speed, proper to the gage of stock to be welded, can be maintained throughout the full length of the longest seam. With our seam welders of today the speed of welding ranges from 3 ft. to 60 ft. per minute, depending on the gage to be welded.

The machines of today are automatic in their operation; that is the current is automatically switched on and off and the work requires no more than guiding by the operator along the seam. To describe the machine would say that as you see, it resembles a large sized spot welder in appearance and the electrical equipment and electrical characteristics, aside from the interrupter mechanism, are not greatly different from a spot welder. A laminated secondary connects the upper welding wheel directly to the transformer and the same method is used to connect the lower welding horn to the transformer. (Fig. 3) The upper welding wheel, under ordinary conditions, is driven by means of an electric motor mounted on the top of the machine. The speed of this motor is controlled through worm gears and a set of change gears. These change gears provide different speeds at the welding roll for different gages of material and for different kinds of material. In what might be termed a standard machine, (Fig. 4) provision is made to quickly change the roll arrangement from the straight seam to the circular seam. In other words, the side seam of a container can be welded and by simply changing

the lower arm, which is held in a sleeve, and swiveling the upper roll 90 deg., it is possible to also weld the bottom of the container into the shell (Fig. 5).

There has been a decided demand for machines capable of welding 16, 14, 12 and 11 gage. This has necessitated the building of machines heavier in both electrical and mechanical construction. It further required the use of air in order to obtain the necessary increased pressure.

A moment ago I spoke of a standard machine but to be frank, we could hardly be said to have any standard machines. This ma-

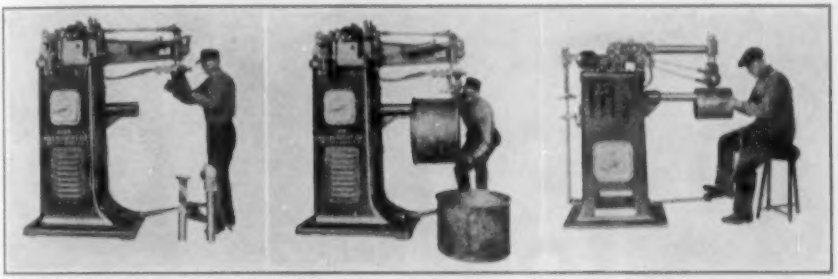


Fig. 4. Standard seam welding machine

Fig. 5. Welding side seam

Fig. 6. Stationary roll type welder

chine comes as near to being a standard machine as possible. It welds both straight and circular seams and is applicable to a considerable variety of work. It is the type of machine that is usually installed at plants where the work varies to a considerable extent. Such a machine as this will come nearer to meeting all the conditions of such work than any other single type. The best results in seam welding, however, are to be obtained, not by building a standard machine but by building each machine exactly for the job. The machines so far shown have the widest field of application and in fact have quite a field of application by simple changes in arm length, sizes of electrodes, etc. We prefer to use this type machine and we designate this type the "stationary roll type" wherever possible because of its uniform electrical circuit. There are quite a few jobs, however, which will not lend themselves to the use of this type of machine. (Fig. 6 Junior.)

Fig. 7 shows what we call the TR machine. Instead of the work traveling, it is clamped down and the roller electrode traverses the seam. This type of machine is advised on small diameters of lengths in excess of 12 in. The cylinder is placed over a mandrel, which mandrel is not indicated in the photo because of the clamps. The mandrel is machined to the exact diameter and by means of the clamps, definite laps are maintained.

There is still another type known as the moving slide machine. (Fig. 8). Its particular application is in cylinders of small diameters and short lengths. The upper electrode remains sta-

the side seam of a container can be welded and by simply changing

tionary. The cylinder is placed over a mandrel which moves in and out and is connected to the source of current.

The building of seam welders is not a manufacturing business. It is distinctly an engineering business. Most jobs call for individual solution. (Fig. 9.) A special problem was presented to us by a prominent stove manufacturer, whose production in linings was not sufficient to justify the purchase of a seam welder each for the straight and circular seams; nor did he have the necessary space to permit of using a combination straight and circular seam welder; a machine of this type necessitates a considerable accumu-

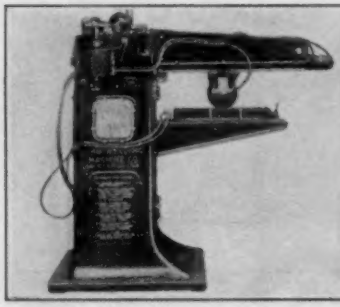


Fig. 7. T. R. type of machine

Fig. 8. Moving slide machine

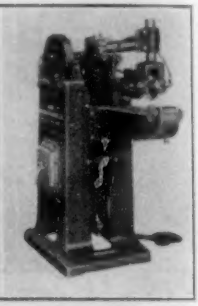


Fig. 9. Special seam welder

lation of partly finished work between the two operations. Inasmuch as the bottoms of his ovens were "dished" or inverted, it was possible for us to construct a machine with the welding roll sufficiently offset from the arm to permit of welding the dished bottoms without any change in the machine from its arrangement for side seam welding. The application of such a machine is limited to diameters of not less than 24 in. or rectangular or square containers with not less than 12 in. sides.

Another solution of a problem is shown in Fig. 10. The machine was built especially for welding milk can breasts to the body of the cans in heavy production. It will be noted that the current conducting bearings are large and of such design as to permit of a quick change of the welding rolls. An adjustable gage stop is provided for locating the position of the lap weld.

In Fig. 11 is shown an unusual seam welder application. The problem was the welding of cylinders 2½ in. in diameter by 22 in. in length. The material was heavily coated terne plate which has been found to require much more heat and much less pressure than steel sheet. The two-roll system was therefore advisable. This therefore required the cooling of an electrode roller and bearing of a diameter less than 2½ in. The only practical solution was to immerse the lower electrode and bearing in a trough of running water. The weld itself was thus made under water. It developed that it was not necessary to guide the cylinder as

the equal distribution of water pressure kept the cylinders in a straight line through the rolls.

The most signal successes in seam welding come from the installation of single purpose machines. This is possible only where there is large production of a single item. Fig. 12 shows a radical departure in the mechanical power employed. In most other types the upper electrode has been driven and the lower electrode has been an idler. The operator has guided the work between the rolls. This method has had its limitations in the speed at which the work could be put through. The above ma-

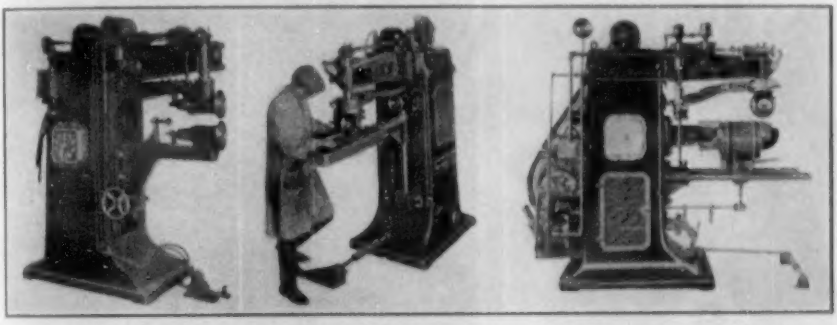


Fig. 10. Machine for welding milk cans

Fig. 11. Machine for welding special material

Fig. 12. A single purpose seam welder

chine is more or less standard in electrical design, except for provisions for materially increased capacity. Both the upper and lower electrodes are idlers. Power is derived from a motor driven oilgear moving a piston to which the holding fixture is attached. When it arrives at the end of the stroke it automatically returns through the action of a double automatic valve.

Fig. 13 shows the method of gaging the lap. The unwelded shell is shoved into the opened clamp. A lever is thrown which forces the edges of the sheet into the grooves of the gage block. The combination of the clamp and the gage block not only provides a definite lap, but feeds this predetermined lap in the correct position through the welding wheels.

Fig. 14 shows a most highly developed type of seam welder and one which of course has very limited application. It is designed exclusively for the manufacture of barrels. The roller electrodes here also are idlers and the oilgear also furnishes the power to move the carriage. The carriage is a mandrel over which the barrel shells are placed. The barrel is held in position by force exerted by electro magnets contained in the mandrel. The operation of the machine is simple. The barrel is thrown over the mandrel. A foot lever is depressed and the barrel is securely held in position. The other foot lever is pressed, and the mandrel with the shell moves forward bringing the edges to be welded between the idler electrode rollers. On completion of the stroke

the barrel shell is completely welded and the carriage automatically returns to its original position. The welded shell is removed as the carriage returns.

The seam welder in Fig. 15 has a very wide field of application. Among the applications might be mentioned lead kegs, small tanks, ovens, automobile mufflers, automobile heaters, automobile fenders, automobile bodies, automobile filters, garbage cans, oil delivery cans, steel barrels, ice cream cans, railroad torches, oilers, gas heaters, coffee pots, oil stove parts, thermos bottles, electric

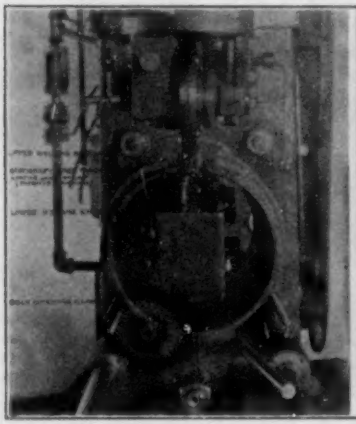


Fig. 13. Method of gaging lap

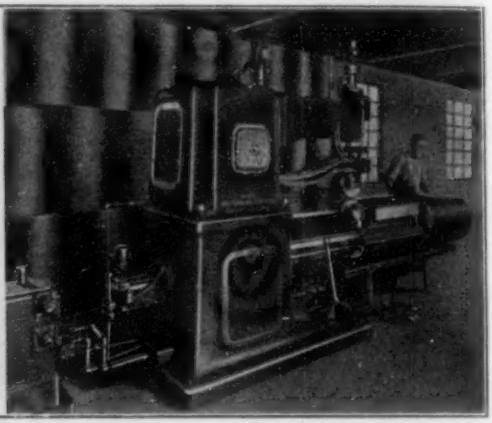


Fig. 14. Highly developed seam type welder

washer tubs, monel metal tubs, ice box linings, and many other products.

There are questions which naturally arise in connection with seam welders, such as, "What is the power consumption?" This is rather a broad question and is dependent upon so many factors such as gage of material, speed of operation, and above all else, comparative loading and welding time. It is seldom that an installation will run over 8 KW per hour and seldom under 4 KW per hour or an average of 10 KW per hour, which, at 2c. per KW, would amount to 20c. per hour.

Another question which is frequently asked us is, "How fast can you seam weld?" This also is contingent upon a number of factors, such as gage of the material, how strong and to what extent must the seam be leak-proof, how accurately is the work being held to its passage through the rolls, and so on. On one of our highly developed machines on which there is a very accurate gage and jig used, it is possible to attain an extremely strong, leak-proof seam at the rate of 60 ft. per minute. The gage of the container is No. 24 gage. A machine of this speed, however, must be made for one single product and for large production in that product. Machines are usually provided with a speed of approximately 9 ft. per minute on No. 18 gage metal.

The speed must of necessity be materially decreased on any gage heavier than No. 18 gage.

It has been possible to very nearly double the production of our early installations of seam welders through the use of a special spot welder (Fig. 16) equipped with a gage block by which a shell may be spot welded prior to the seam welding operation. The first thought of a manufacturer when this spot welding operation is mentioned is that it adds an operation. As a matter of fact, spot welding is no more of an operation than is the operation

Fig. 15. Illustrating output of seam welders

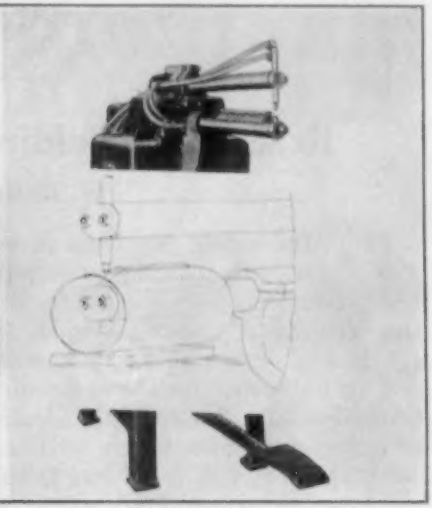


Fig. 16. Special type machine

of putting the shell between clamps or spot welding on to the seam welder itself, and since the especially equipped spot welder can do this operation of jigging or clamping faster, the use of spot welders for such a purpose is only logical.

An important thing to be remembered regarding seam welding and spot welding as well is that a great deal of bad results are eliminated by insisting on clean stock. Seam welders have successfully welded steel, terne plate, tin plate, light gage soft brass, zinc, nickel, monel metal, nickel silver and various alloys in production. They have also successfully welded galvanized stock but it has never been recommended for production for the reason that the spelter adheres to the rolls and causes difficulty. We are working on a means of overcoming this. A peculiar thing in connection with the welding of galvanized stock is that the welds do not rust.

Various gage sheet from No. 30 gage to No. 11 gage have been welded in production. It is entirely likely that even heavier stock can be seam welded successfully.

One of the biggest features in connection with the successful

installation of seam welders is the engineering service upon which we insist. Good seam welding is a product of the proper amount of heat, the proper amount of pressure and the proper speed. It is necessary to adjust these three variables to suit the job. It cannot be prescribed as in a textbook but has to be worked out on the job. After the machine is set it will be seen that there are no variables either mechanical or electrical. Identical conditions are applied on each weld with a natural duplication of results. Summing up, the seam welder is still another example of a labor saving device in which production is not alone increased, but a superior and more uniform product results.

Resistance Welding Truck Wheels*

W. REMINGTON†

From the many problems in resistance welding that have been met and solved, it is impossible to say which is the most interesting. Some are interesting from the standpoint of speed, such as the welding of overall buckles, in which case a speed has been reached of 4800 welded buckles in an hour, as there are only 3600 sec. in an hour, the above production means that a buckle is fed to the machine, welded and ejected in about ¾ sec., or in the case of automobile rims where with automatic welders a production of over 5400 rims in 9 hr. has been met. These latter machines do not have any automatic feed attachment, but the welding is done automatically and the operator does not have to be a skilled man excepting in the point of handling the rims rapidly.

Some problems are interesting from the point of quality of the welds, such, for instance, as was the case in the welding of certain automobile hubs. In this case the hub was made up of two parts, each consisting of a disk with a projection on one side very much like the face plate of a small lathe. These parts were forgings which showed a much higher quality of material than would have been the case had the hub been made from a steel casting. These parts were then placed in a welder and were welded together so that the resulting product made up the hub consisting of a cylindrical center with a disk or flange on each end. This weld, of course, came in approximately the center of the cylindrical part, and it was absolutely necessary that the metal in the weld and in the adjacent neighborhood should be of the same hardness and have the same physical qualities as the rest of the metal. Otherwise the strains would not be properly distributed when the hub was under stress. If the welded section were softer or more yielding than the rest of the material, the distortion due to the stresses

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*Presented at March, 1927, Meeting, New York Section, A. W. S.
†Chief Engr., Thomson Electric Welding Co.

One of the biggest features in connection with the successful

would be greater in this region than in others, but on the other hand, if the welded section were harder than the surrounding material, that section would not yield, and all the stressing would be localized into the softer and more yielding part of the hub.

In addition to the requirements as to quality of the weld, it was required in this article that the overall dimensions after the welding takes place must be within the limits of 0.015 in. plus or minus, that is, the completed welded part must be sufficiently accurate so that the overall length of the hub and the squaring up of the flanges

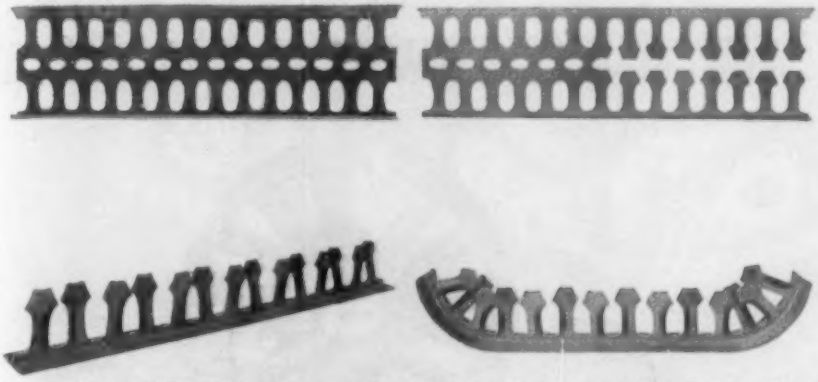

Fig. 1. (Upper left) "I" beam put through press and openings punched out. Fig. 2. (Upper right) Additional parts punched out. Fig. 3. (Lower left) Teeth of spokes slightly dished and staggered. Fig. 4. (Lower right) Bending process started

would not require more than approximately 0.015 in. machined from each end. These requirements were met by using a very rigid machine in order to get the accuracy in the point of dimensions and by having the adjustment such that the weld was actually completed before the hub was pushed up to its minimum length. The current was allowed to remain on after the weld was made and pressure applied, which finally forged the hub to a proper length and with the flanges parallel. After the parts were taken from the welder they were heat treated.

Some problems have been interesting from the standpoint of clamping the parts in the welder and holding them while the weld was being made. One instance of this kind is the problem of welding the rims of tractor wheels after the hub and spokes have been put in place. In this case the ordinary clamp, such as a bar going across the rim or an arm reaching across the rim, cannot be employed due to the interference brought about by the presence of the spokes. It is necessary in a case of this kind to devise a clamp which consists of four clamping jaws, two coming in from each side of the wheel with the open ends to be welded together between them. The spokes are only loosely in place before the welding is completed, but as the weld is being made, the rim is being shortened in its circumference, and consequently drawn down further and further on the spokes and finally it is drawn up tight against

the shoulders on each spoke. This tightness must occur at or just after the time that the weld itself is completed. As wheels of this kind will come to the welder with the ends of the rims to be welded anywhere from 1 in. apart to 2 in. or 3 in. apart, the platens or moving parts of the welder must have extraordinary travel in order to permit of the clamps gripping the rim at the proper distance from the end to be welded. The clamps must be very powerful and have great gripping power as the rims are not perfectly formed, and it is necessary for the clamps to spring the rims down into good contact with the dies as well as to hold the rims against slipping when the pressure is applied.

The problem of welding large cross sections such as 25 to 30 sq. in., is also interesting, but principally from the point of electrical

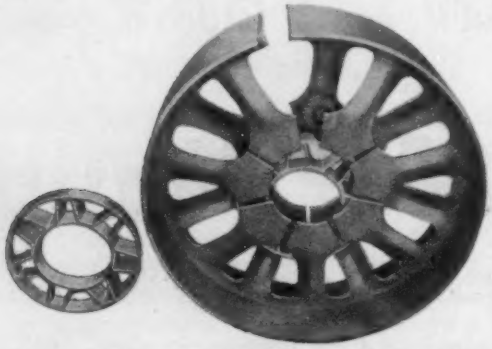

Fig. 5. Shape bent into nearly complete circle

design. Welders for this size work will be capable of drawing from 850 to 1000 k.v.a. and have pushup pressures of 50 tons and over. The current passing through the weld will probably amount to approximately 100,000 amperes, so that the problem of joints and conductors in such a machine is very interesting, particularly when you consider that the mechanical features of the machine must be maintained, and in many instances run in direct conflict with the electrical engineer's desires.

The welding of the Bethlehem rolled steel truck wheel is an interesting proposition from several angles; its inception and design, the problem of holding, the pressure required, the fact that the weld had to be finished after a definite amount of pushup, also the amount of current used. The wheel was invented by a welding engineer who had spent practically his whole time for quite a number of years on welding problems and especially problems involving the use of structural steel. Not only was the invention of the disc wheel very unique, but the actual development and method of manufacture required an immense amount of ingenuity and a large amount of money, as the cuts and following descriptions will show. In order to convey any reasonably clear idea of

this proposition, it will be necessary to describe briefly how the wheel is made and then describe the welder and its operation.

Two wheels are made from one "I" beam, the length of which is approximately the circumference of the wheels. The "I" beams are rolled to get the proper thickness of the web in proportion to the flange and of a width of approximately the diameter of the finished wheel. The "I" beam is then put through a press which punches out openings as shown in Fig. 1. It is then put through another press which punches out other parts of the beam and di-

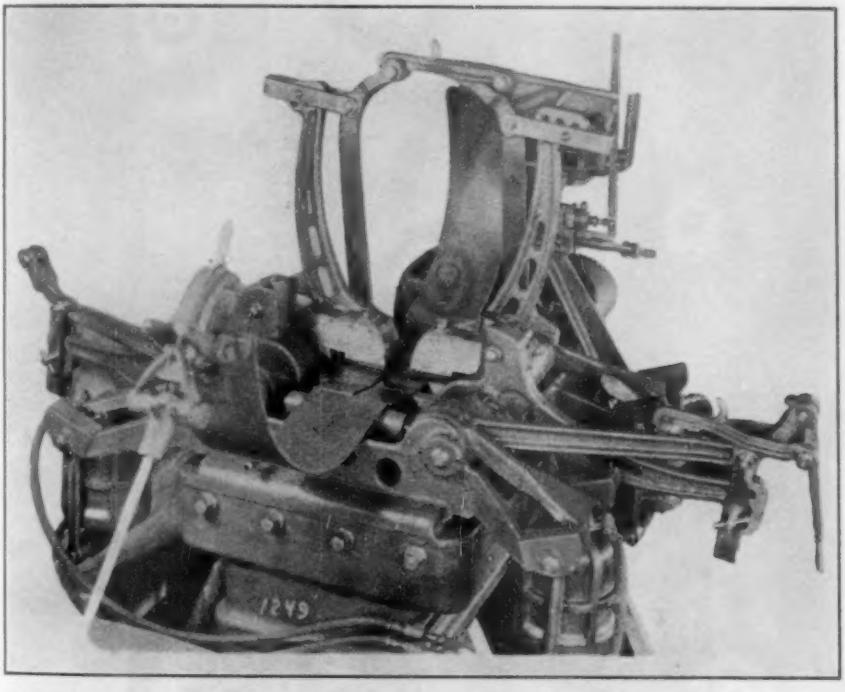

Fig. 6. Top view showing clamp detail

vides it into two parts, as shown in Fig. 2. You will note that now each part of the beam resembles roughly a large comb, the lower ends of the teeth of which are enlarged and at their extreme ends, a little concaved. These teeth form the spokes of the wheels after the rim is rolled up and the enlarged ends come together and keystone to form a continuous mass around the hub. The concaved ends mentioned above will now form a complete circle and fit over a shoulder provided in the hub of the wheel.

Fig. 3 shows these teeth or spokes slightly dished and staggered. Every other spoke is bent in the same direction, a few degrees out of the perpendicular plane to the rim, and the intervening spokes are bent out the same way, but in the opposite direction. Fig. 4 shows the starting of the bending process, in which the ends of

the "I" beam back to about one-quarter of the length, are bent into approximately 90 deg. arcs. The section of this shape is then put into another large press especially made, and of a very ingenious design, which completes the bending until the beam is bent into a complete or nearly complete circle, as shown in Fig. 5. You will note in this picture that the ends of the wheel are not brought absolutely together. You will also note that the large ends of the

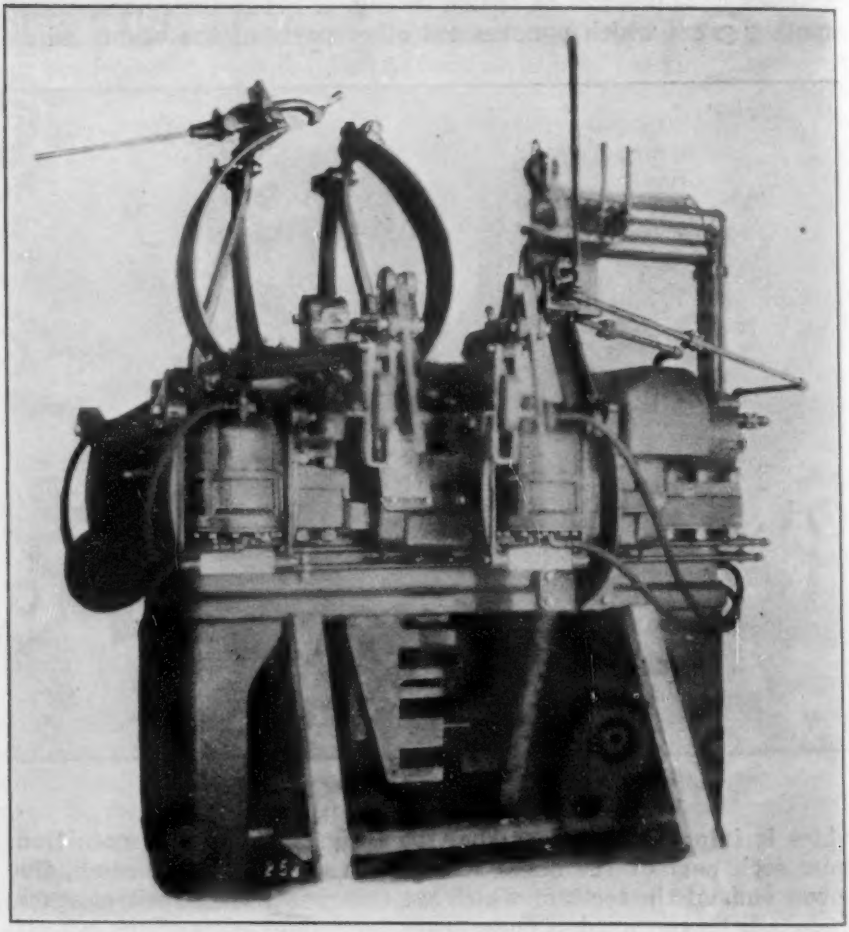

Fig. 7. View showing clamps open

spokes have not come completely down into position. In this state the wheel comes to the welder and in the welding process the rim must be perfectly welded and must also be reduced in its circumference until the large ends of the spokes keystone together, as mentioned above, and form practically a continuous disc around the center.

Incidentally, the edges of these spokes are not welded together—

they are simply brought in tight contact and are later held in permanent location by means of the bolts which hold the hub in place.

There are more processes to follow, of course, in the completion of this wheel, and there are some other parts which go into it, such as a central spacer between the spokes at the hub and the hub part itself. We will not go into the detail of these parts, however, as they do not directly affect the welding. From this last picture

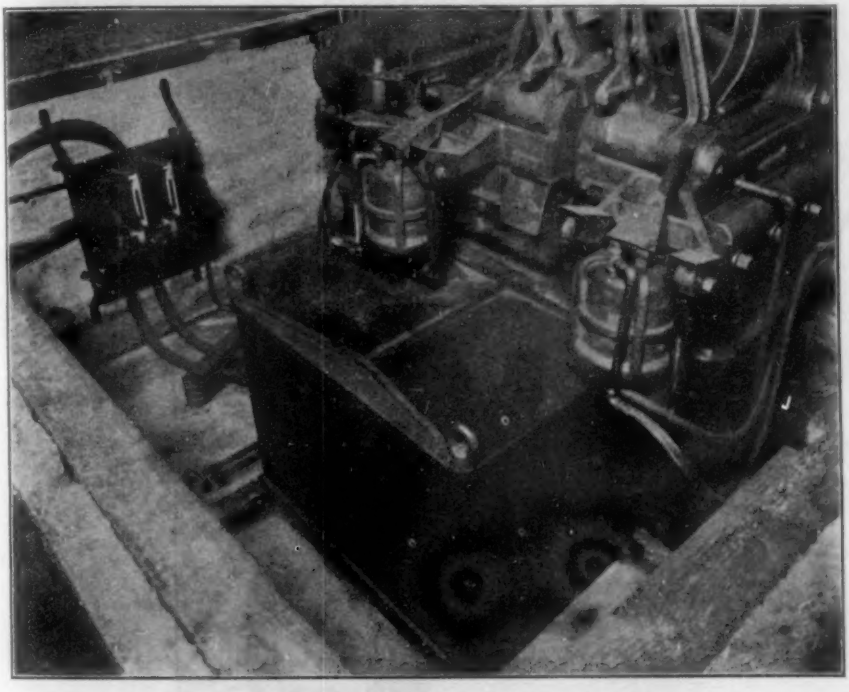

Fig. 8. Rear view showing transformer in place

showing the wheel as it comes to the welder, you will note that at the outer end of the spokes there is a web which runs all the way around the circumference of the wheel. This web may be 2 in. deep or more, and its purpose, of course, is to give strength and stiffness to the wheel, but in giving stiffness and strength to the wheel it very materially adds to the difficulty of welding, it complicates the design of clamps, it takes up room that we would like to use for clamping, and it also requires that the clamps be much stronger in order to hold the rim and bend it against the resistance of this web.

In the ordinary problems of welding we simply take the area in square inches of cross section to be welded and multiply that by a certain number of pounds per square inch which we decide to be necessary in order to obtain the quality of weld desired, but in this case we had to add to this figure the amount of pressure required

to bend this wheel and reduce it sufficiently in its diameter to not only complete the weld but to bring the spokes in their proper position. Ordinarily flat pieces of stock 12 in. wide or more would be welded by laying the stock flat on the top of the welder, the ends to be welded projecting a little bit beyond the dies on which the stock rests. There would then be a lever or arm which would extend across the top of each piece of stock so designed that either

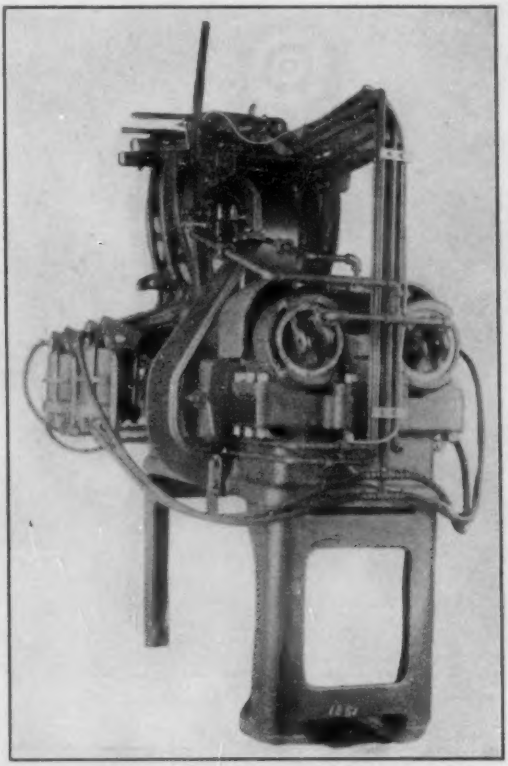

Fig. 9. View taken from pressure end of welder

by means of air pressure or manually, it would clamp down on the stock with sufficient force to not only make a good contact with the copper die underneath, but to hold the stock against slipping when the ends are pushed together to complete the weld.

While the largest cross section to be welded on these wheels, I believe, was either 16 in. or 20 in. wide and about ¾ in. thick, in addition to this there was a web, the ends of which would include perhaps 3 sq. in. In order to provide sufficient pressure for welding such a cross section and also overcome the resistance to bending due to the stiffness of the wheel, the welder was provided with a pushup capacity of 50 tons. You can readily judge from the picture of the wheel as it comes to the welder that it would be impos-

sible to get an arm or lever between the spokes and over the web of enough strength to clamp down this rim sufficiently tight to keep it from slipping when the pressure of 50 tons was exerted on the pushup. The clamping device finally designed and built for this wheel was rather complicated, and consequently difficult to describe. However, it primarily consisted of a band which went entirely around the wheel when the wheel was in place on the welder, the lower ends of which band were fastened to the platens of the welder by a hinged joint. This band withstands all resistance to bending and welding afforded by the wheel when the platens are pushed together to make the weld. The clamping arms proper were only required to bring the rim of the wheel down into sufficiently tight contact with the dies to afford the flow of current

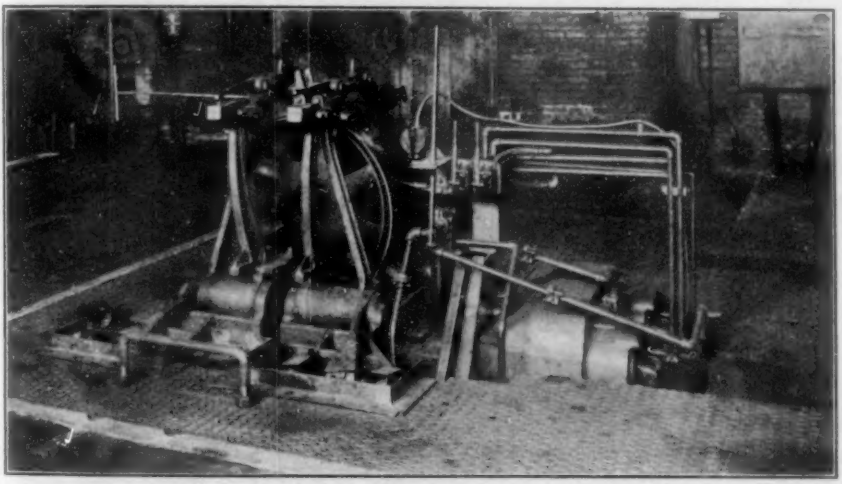

Fig. 10. Control of pressure and current seen in this picture

and to hold the ends of the rim in proper alignment. There were four of these clamping down arms, two coming in from each side of the wheel, leaving a space for the spokes to come up between the ends of the arms, and, of course, one pair clamps down each end of the rim.

Fig. 6 is a view looking diagonally down on to the top of the welder. You will note the broad bands which are thrown back toward the ends of the machine. This is the band referred to above as being clamped around the wheel and absorbing all resistance to the bending during the welding operation. You will also note the four clamping arms and jaws referred to above as holding the rim down against the copper contacts. The two arms nearest are thrown open so that the jaws themselves stand in a vertical position ready to receive the rim of the wheel. The other two arms further away up into position just as they would be with the rim being clamped. You will note that these arms after being

brought up into position are tied together across the top with the linkage. The real clamping effect comes through the turning of an eccentric on which the arms are hinged. The turning of this eccentric is by means of air cylinders, there being four air cylinders in all, one for each clamping arm.

Fig. 7 is another view of the machine taken from the back. Two of the air cylinders are in evidence and also the clamping band. The transformer for this machine rests on the floor back of the machine, but was not in place when this plate No. 7 was made. The big castings projecting downward are about the middle of the machine and which contain the large slots in evidence are really copper terminals for receiving the flexible secondary leads coming from the transformer. These copper terminals weigh about 1500 lb. apiece.

Fig. 8 is also a rear view of the machine having the transformer in place. You will note that both the machine and the transformer are placed down in a pit, and that the transformer is completely housed in as a protection against dirt and flying particles of iron or steel which are thrown off when the weld is being made. The two cylinders showing are air cylinders for operating the clamping arms.

Fig. 9 is a view taken from the pressure end of the welder. The two items which look like pistons are really the two hydraulic cylinders which are utilized in obtaining the 50 tons pushup mentioned above. These cylinders are held in place in the frame in very much the same manner as the breech block of a field gun.

By putting a rod through the holes shown in the cylinder and twisting them through 90 deg., they can be drawn out of the castings which hold them in position. From this view you get a good idea of the amount of piping necessary on a machine of this type. This piping being so much in evidence is partially due to the fact that the controls of both air and pressure, as well as electrical control are brought to one point, which is better seen from Fig. 10. The long lever controls the movement of the platen in making the weld and in getting the platens into proper position for the succeeding weld. The small levers at the right of the long lever are for controlling the clamps, while to the left of the long lever is the switch for starting the flow of electric current.

Fig. 10 shows the welder as actually installed down in a pit so that the top of the welder comes flush with the floor. This plate also shows the wheel clamped in place ready for welding.

The actual welding time for welding a wheel about 12 in. wide and ¾ in. thick would probably be under 40 sec. How much under would depend upon the skill of the operator and the character of weld desired. The time might even go as low as 20 sec. The production of wheels per hour, however, probably would not exceed 20, due to the fact that the wheels are hard to handle and get into place.

This machine has an electrical capacity of 600 k.v.a. and a push-

up capacity of 55 tons. The machine itself occupies a space of about 8 ft. x 10 ft. x 5 ft. high to the top of the dies and weighs approximately 10 tons.

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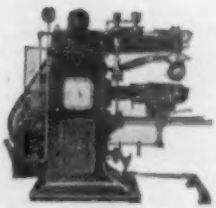

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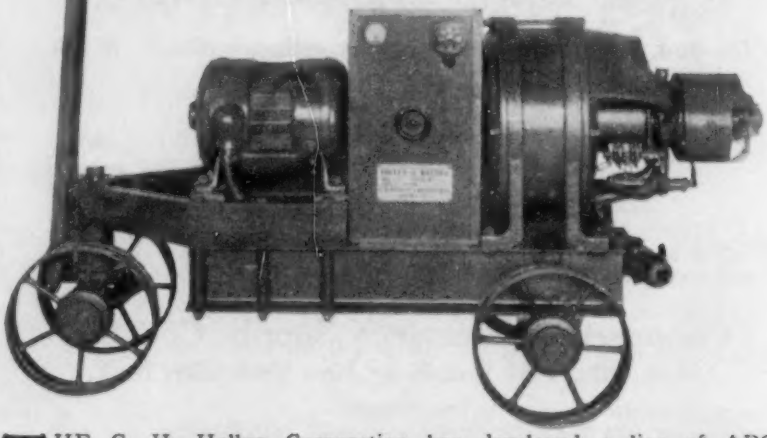

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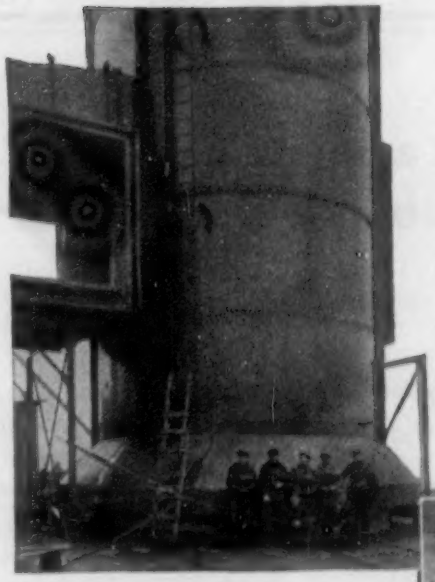

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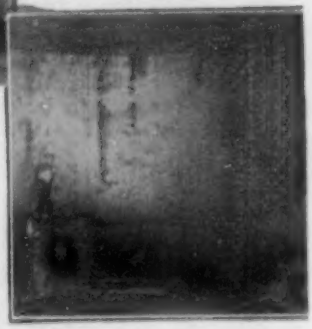

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And every inch of the 1½ miles of welding in the stack pictured above was made with Wilson Welding Machines and Wilson "Color-tipt" Welding Wire—Grade No. 17 (patented U. S. A., June 13, 1916; March 9, 1920) diameter 5/32", at 150 amperes. The third of the seven stacks is now in process of construction.

In addition to the 52,500 feet of welding in the seven giant stacks, the seams on the horizontal flues between the stacks and in the cinder catcher are being welded, and all rivets welded over as protection against corrosion. The rivets are being welded over with Wilson Grade No. 0. The seams are being welded with Wilson Grade No. 9 (patented U. S. A., June 13, 1916; March 9, 1920) diameter 5/32", at 145 amperes.

No matter what industry you are in, there is a grade (analysis) of Wilson "Color-tipt" Welding Wire that will meet your own particular welding needs. Write today for a sample—just indicate the kind of metal you desire to weld. Also, ask for bulletins describing Wilson Welding Machines.

WILSON WELDER & METALS CO. INC., WILSON BLDG., HOBOKEN, NEW JERSEY

WILSON

WELDING MACHINES AND WELDING WIRE

Not a single defect in 20,000 oxwelded joints*

SO RELIABLE and standardized is the laying of oxwelded pipe lines for gas and oil, that a well-organized crew will run a hundred miles or more of pipe without a single defective joint.

In fact, trained operators working under procedure control have put lines into service without making any pressure or proof tests whatever and the results have been perfectly satisfactory.

More important evidence is that periodic inspections by line walkers have been discontinued. They were found to be unnecessary on welded lines. The inspectors never found anything to report.

This is remarkable when one remembers that the lines are laid in summer and that during the winter there is frequently a 90-degree temperature drop, producing temperature stresses as high as 25,000 pounds per square inch. And in addition to all this, oil lines operate under a liquid pressure of 650 to 750 pounds.

Linde Engineers will be glad to advise you on Linde procedure control for making welded pipe joints. Other Linde procedure controls cover a wide variety of applications of the oxy-acetylene process.

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
General Offices: Carbide and Carbon Building
30 East 42d Street, New York
32 PLANTS 102 WAREHOUSES

LINDE OXYGEN

* No. 5 of a series of advertisements on the engineering phases of oxy-acetylene welding and cutting. Send for the booklet entitled: "Engineering and Management Phases of Oxwelded Construction."

The final cost of oxwelding

The success of the oxy-acetylene process and the remarkable growth in the extent and variety of its applications are convincing testimony that oxwelding is economically sound.

It is not possible that one gas company after another should have adopted oxwelded pipe lines unless there were both economy of installation and economy of upkeep. Plant after plant would not have standardized on oxwelded tanks and welded equipment if it were not sound operating policy. Thousands of engineers and operating executives sponsor the oxy-acetylene process by using it.

The final cost of the gas-welded joint, because of its greater ruggedness, longer life and elimination of maintenance, is always lowest.

Prest-O-Lite

DISSOLVED ACETYLENE

22 years old and still growing

THE PREST-O-LITE COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
General Offices: Carbide and Carbon Building
30 East 42d St., New York
31 Plants—66 Warehouses

Oxweld equipment is not built for stunts

TRICK STUNTS may sell equipment—once. But Oxweld equipment has been made and sold for fourteen years (since the beginning of the welding era) and it is going to be made and sold for years to come.

Oxweld won't make or sell equipment that is built just for stunts that have no real bearing on the actual use of the equipment. Oxweld equipment is designed for efficient service.

That's why *your* Oxweld injector blowpipes for welding or cutting will still be doing business in five years and in ten years.

There are thousands of veteran Oxweld blowpipes still earning their daily wage as well as they did five and ten years ago. They are built "for keeps," for service and for ultimate economy.

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Unit of Union Carbide and Carbon Corporation
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STOCKS IN 30 CITIES

Oxweld
WELDING AND CUTTING APPARATUS

This
is G-E Arc Welding Service

The G-E Arc Welding School: Free instruction in arc welding. Conducted in the interest of better welding. The best-equipped and the best-known school of its kind.

G-E Arc Welding Specialists: Ready to serve you without obligation in the working out of any welding problem. Call your nearest G-E office.

G-E Research Laboratories: Constantly at work in the interest of better arc welding. The answer to your peculiar welding problem may already be in their files.

Practical Demonstration Shop: Send in samples of your work. The most suitable welding methods will be worked out. A report will be submitted with complete application and cost data and our opinion as to whether or not the work should be arc welded.

G-E Arc Welding and Cutting Manual: One of the most complete practical arc welding manuals in existence. 145 pages —195 illustrations. Invaluable to all operating executives interested in welding. Price $1.

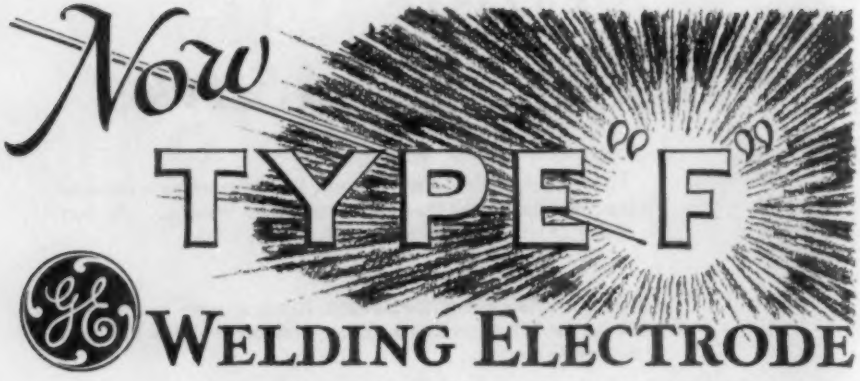
A Store House of Information: Bulletins, pamphlets, descriptive leaflets, instruction books, etc. covering all types of equipment and all phases of welding work. You are welcome to copies.

This is G-E Arc Welding Service. Whether or not you use G-E equipment you may make use of this service. Your inquiries will be promptly attended to.

530-26D

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN PRINCIPAL CITIES



WELDING ELECTRODE

TYPE A
for use on cast iron.

TYPE B
for use with automatic welders.

TYPE F
for general welding of steel.

The success of Type B, G-E Welding Electrode in automatic welding, prompted the development of Type F for general steel welding.

The new Type F has the desirable characteristics of Type B in a new form.

It has stability, uniformity, and produces clean, strong welds.

Its stability permits an operator to deposit more metal with a given current consumption.

Its uniformity provides good working conditions continuously. Clean, strong welds make every job a good one.

The new Type F, treated by a special General Electric process, costs no more than good, bare steel wire and its economy in use is naturally much greater.

A special G-E Welding Electrode Distributor near you will be glad to give you further facts and samples.

Special Distributors for G-E Welding Electrodes

American Steel Eng. Co.,
10 South 18th St.,
Philadelphia, Pa.
also
601 Granite Bldg.,
Pittsburg, Pa.
Bird-Potts Co.,
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Capital Electric Co.,
Salt Lake City, Utah.
Robert M. Hartwell,
353 East 2nd St.,
Los Angeles, Cal.
Industrial Sup. Co., Inc.,
329 East Second St.,
Los Angeles, Cal.
Hendrie & Bolthoff Mfg. & Supply Co.,
Denver, Colo.

F. F. McDonald & Co.,
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Matthews Electric Sup. Co.,
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National Welding Equip. Co.,
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120 Liberty St.,
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W. A. Ramsey, Ltd.,
74 Queen St.,
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Oliver H. Von Horn Co., Inc.,
523-534 Camp Street,
New Orleans, La.
Welding Service Co.,
50 Church Street,
New York, N. Y.

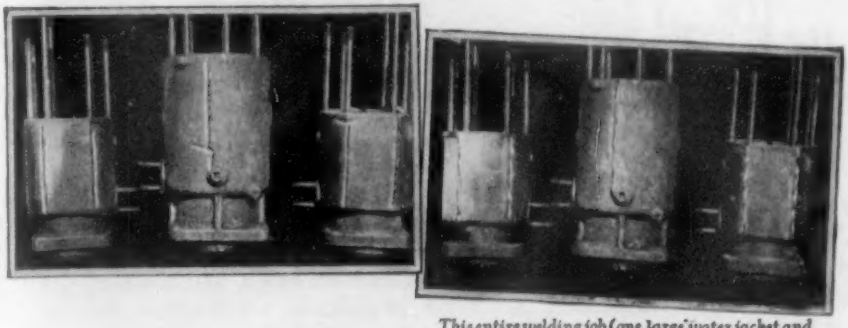
550-13D

GENERAL ELECTRIC

MERCHANDISE DEPARTMENT, BRIDGEPORT, CONNECTICUT

TOBIN BRONZE WELDING

Repairs 3 cracked water jackets in ninety minutes



This entire welding job (one large water jacket and two small ones) required 2½ lbs. Tobin Bronze, 20 cu. ft. oxygen and 20 cu. ft. acetylene.

TOBIN Bronze Welding by the oxy-acetylene process saved time and money on this job. These cylinder water jackets were cracked by freezing. The large one, taken from a 75 H.P. caterpillar tractor, had an 18" crack. The smaller ones, from 60 H.P. tractors, had cracks averaging 12" long.

In every case, the cracks were beveled to within 1/16" of the thickness of the metal and Tobin Bronze Welded without preheating. The entire job was completed in an hour and a half.

Because of the low temperature required, 1650° F., Tobin Bronze Welding usually eliminates preheating, and minimizes distortion and metal shrinkage, thus making it possible to control the alignment. Tobin Bronze permeates the cast iron and knits the broken parts together in a permanent bond stronger than the casting itself. Tobin Bronze welds in cast iron, properly made, cannot break at the weld.

Many manufacturers who have proved the value of Tobin Bronze Welding in repair work are now using it to save time and money, or to improve quality, in their manufacturing operations.

Tobin Bronze Welding Rods may be obtained from distributors of welding equipment and supplies. Look for the trade-mark Tobin Bronze—it is stamped in every rod.

THE AMERICAN BRASS COMPANY
GENERAL OFFICES: WATERBURY, CONNECTICUT
Offices and Agencies in Principal Cities
Canadian Mill: ANACONDA AMERICAN BRASS LIMITED
New Toronto, Ontario

TOBIN BRONZE
REG. U.S. PAT. OFF.
WELDING RODS

EXCLUSIVELY AN ANACONDA PRODUCT

Before you settle on the type of machine get the users viewpoint

Any Lincoln office below will put you in touch with a user near you whose experience covers many types of welders. Get his viewpoint based on experience.

They say

(a new list in each issue)

"A machine of this kind in use continuously pays for itself in less than one year."

* * *

"In May, 1919, we purchased one of your portable electric welding outfits which has given satisfactory and practically continuous service to date covering both light and heavy general factory production and repair work."

* * *

"Comparative time study figures show that electric welding saves us considerable time over our old method of gas welding."

* * *

"We might add that we are well pleased with the welder and feel that it is an indispensable addition to our equipment."

* * *

"We formerly welded these tanks by gas and can save from 15c to 25c per hour of operation with the electric weld according to the gauge of material used."

LINCOLN "Stable Arc" WELDER

The Lincoln Electric Co.

General Offices and Factory:
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Boston
Buffalo
Charlotte, N. C.
Chicago
Cincinnati
Detroit
Des Moines
Grand Rapids

Branch Offices
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Milwaukee
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New York City
Philadelphia
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The Lincoln Electric Co. of Canada, Ltd., Toronto-Montreal
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THIS WELDING JAW

ELKONITE
resistance welding
ELECTRODES
stand up
where copper
FAILS.

Is being used by one of the largest automobile wheel manufacturers for flash welding automobile rims, because of the great saving it affords over all other materials in productivity, material, time and shrinkage. Elkonite is proving to be the answer to many important problems in resistance welding operations—flash, projection, spot welding, especially aluminum and brass, cross-wire, electrical upsetting of rivets, etc.

Descriptive data on request.

ELKON WORKS, INC.
WEEHAWKEN, N. J.

Exclusive licensees under General Electric Co. patents dated May 28, 1925 and September 1, 1925. Other patents pending to Elkon Works.

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A number of Bound Volumes of the Journal for 1926 have been bound in attractive book form. Members may obtain copies at $5.00, non-members $10.00.

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SHAWINIGAN PRODUCTS CORPORATION
110 WILLIAM STREET · NEW YORK
1404 OLIVER BUILDING · PITTSBURGH

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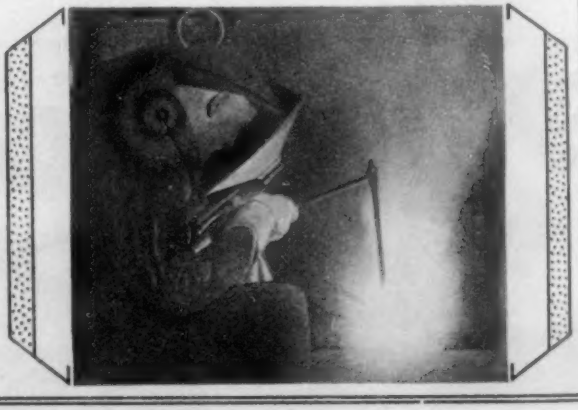
ROEBLING
Wire

WELDING WIRE can always be relied upon for uniformity and perfect flowing quality. Roebling Electrodes are carried in all the standard sizes (14 inch lengths), also Gas Welding Wire (36 inch lengths). Other sizes required will be manufactured to order. Tell us the kind of metal you desire to weld—we will supply the wire which will give the best results.

Send for booklet A-529

John A. Roebling's Sons Company
TRENTON, NEW JERSEY



THERMIT WELDING

For heavy welding operations
in all fields

Railroad Industrial Marine

METAL & THERMIT CORPORATION
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Pittsburgh Chicago Boston S. San Francisco Toronto

Why Experiment?

Torches
Regulators
Generators
Compressors
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Paint Sprays
Carbide Lights

Catalog 54?

SINCE the infancy of the industry, expert engineers and skilled workmen have maintained the predominance of Milburn Equipment.

Its acceptance as standard equipment by large industrials, railroads and Government Departments the world over exemplifies Milburn leadership.

THE ALEXANDER MILBURN CO.
Baltimore, Md.

How does a suitable rod coating material influence the stability of the arc, the speed of welding, the hardness, strength and ductility of the weld metal? These questions are fully discussed in Bulletin No. 119 —UNA Welding Rods. Have you a copy?

UNA WELDING AND BONDING COMPANY
CLEVELAND, OHIO

Welding Processes
Welding Rods

UNA

A.C.-D.C. Welders
Welding Supplies

WELDING *and* CUTTING EXPOSITION

Auspices American Welding Society

In Co-operation With

National Steel *and* Machine Tool Exposition

CONVENTION HALL

DETROIT

September 19, 20, 21, 22, 23, 1927

THE annual fall meeting of the American Welding Society will be held in Detroit the same week. A special section of the exposition building has been set aside for the welding industry (60% already reserved) and it will be part of one of the largest industrial expositions in the country.

DETROIT is a splendid market. You will surely want to be represented and take advantage of this once-a-year opportunity to put your product right before the eyes of 80,000 metal and welding trade executives, just at a time it will have their wholehearted and interested attention.

For complete information, floor plans and rates, write

American Society *for* Steel Treating

4600 Prospect Avenue :: Cleveland, Ohio

MEMBERSHIP APPLICATION BLANK

AMERICAN WELDING SOCIETY

33 WEST THIRTY-NINTH STREET
NEW YORK, N. Y.

.....192..

Secretary:

I hereby apply for Class.....Membership in the .....Section of the AMERICAN WELDING SOCIETY and attach hereto remittance of $..... for first annual dues. Remittance will be refunded in the event of rejection of applicant. I also agree to abide by the Constitution and By-Laws of the Society and By-Laws of the Section.

Name .....

Present occupation .....

Name of Company and Address .....

Residence .....

Address for mailing .....

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Applicant is requested to state here length of welding experience and processes involved, also to record any technical or mechanical experience.

References: (1. .....

(at least two) (2. .....

Proposed by .....

(See other side)

CUT OFF ALONG THIS LINE

QUALIFICATIONS FOR MEMBERSHIP

Extract from By-Laws

ARTICLE I.

Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the cases of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues..... $100.00

Class B Members, being individuals interested in the science and art of welding, with full rights of membership. Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues..... $20.00

Class C Associate members with right to vote but not to hold office, except in Sections as may be provided for by the By-Laws of the Section. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding, are also eligible to this class.

Annual dues..... $10.00

Class D Operating members, who are welders or cutters by occupation, without the right to vote or hold office except in Sections as may be provided for by the By-Laws of the Sections.

Annual dues, United States and Canada $5.00
Other countries..... $10.00

Class F Student Members, who are actually in attendance at any one of the recognized colleges and approved trade schools, without the right to vote or to hold office except in sections as may be provided for by the By-Laws of the Section.

Annual dues..... $2.50

PAGE-ARMCO
PROCESSED
Welding Wire *and* Electrodes

first choice for perfect work

In every state in the Union, in Canada and foreign countries—for every type of welding—Page welding wire and electrodes are being specified for perfect work because they have proven their superiority.

One reason for Page superior quality lies in the exclusive Page method of processing all wire and electrodes to meet the exact requirements of the work to which they will be placed. They are shop tested to determine welding qualities and are constantly uniform. Each piece is plainly marked.

Write today for sample of wire and complete information. No obligation.

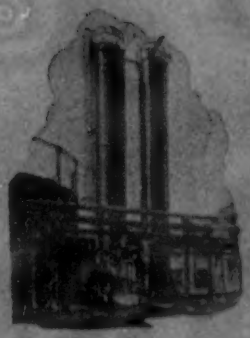
PAGE STEEL AND WIRE COMPANY

An Associate Company of the American Chain Co., Incorporated

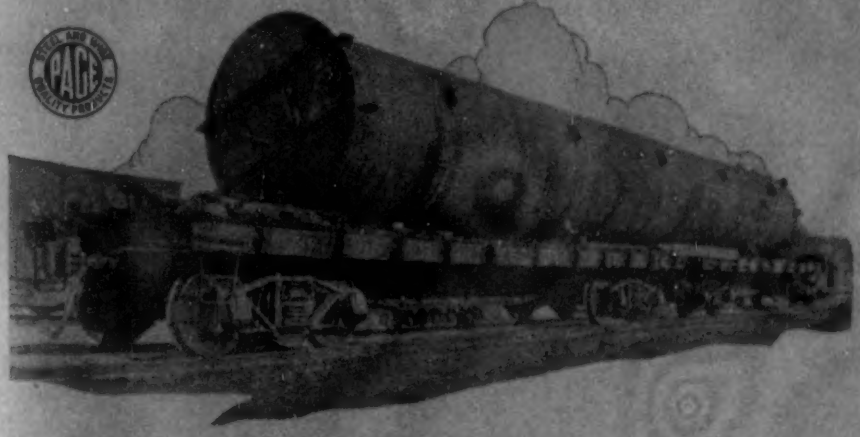
Bridgeport, Connecticut

District Sales Offices:

Chicago New York Pittsburgh San Francisco



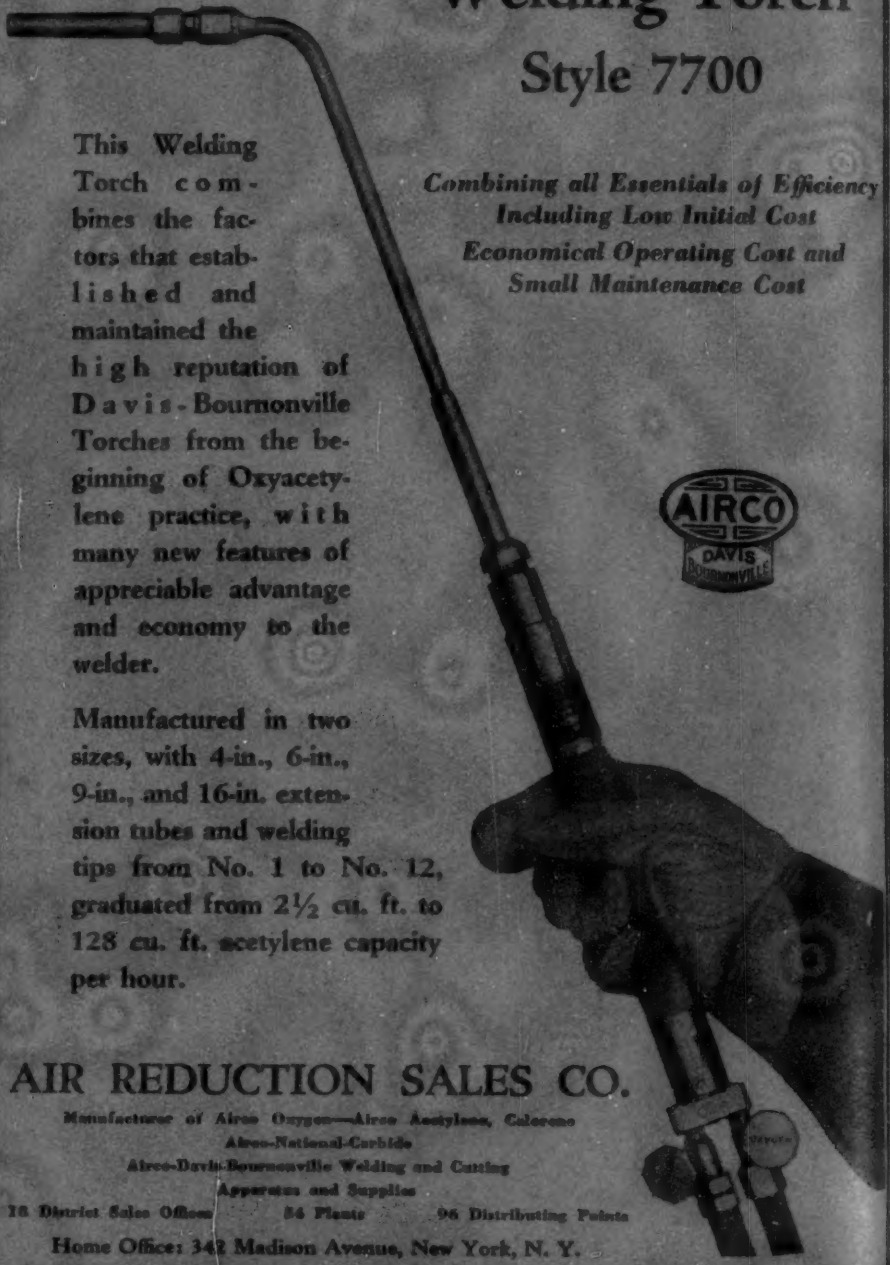
The illustration shows a water cooler, 60 ft. long, 7 ft. in diameter and weighing 51,000 pounds. It was fabricated of Armco Ingot Iron plates by the Waterous, Limited, of Brantford, Canada, for the Hamilton By-products Coke Company. Electrically welded throughout with Page-Armco welding wire on semi and full automatic machines.



An Airco-Davis-Bournonville

Welding Torch

Style 7700



Combining all Essentials of Efficiency
Including Low Initial Cost
Economical Operating Cost and
Small Maintenance Cost

This Welding Torch combines the factors that established and maintained the high reputation of Davis-Bournonville Torches from the beginning of Oxyacetylene practice, with many new features of appreciable advantage and economy to the welder.

Manufactured in two sizes, with 4-in., 6-in., 9-in., and 16-in. extension tubes and welding tips from No. 1 to No. 12, graduated from 2½ cu. ft. to 128 cu. ft. acetylene capacity per hour.

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